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I. THE MALAY ARCHIPELAGO.*

NOTHING affords greater relief to the hard-worked scientific littérateur, who is compelled day by day and week by week to pore over the labours and investigations of experimentalists, or to sift the theories of speculative philosophers, until his brain becomes confused with the long lists of new genera and species which are introduced into every province of nature's realm, or with the hypotheses, more or less plausible, propounded by each new thinker, than to cast aside such dry and often uninteresting technicalities, and to follow, though it be but in imagination, one of those free lances of science, the Naturalist Traveller. It is pleasant, indeed, to wander with him through distant regions of the globe, little known to Europeans even by name, to laugh with him at the mute astonishment of his savage acquaintances as he follows his scientific pursuits, or *at* him as he practises a little of that literary archery in which all travellers are supposed to excel.

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* 1. 'The Malay Archipelago: The Land of the Orang-Utan and the Bird of Paradise. A Narrative of Travel, with Studies of Man and Nature.' By Alfred Russel Wallace, author of 'Travels on the Amazon and Rio Negro,' &c. 2 vols. 8vo, with 51 Illustrations and 9 Maps. London: Macmillan & Co. 1869.

2. 'Travels in the East Indian Archipelago.' By Albert S. Bickmore, M.A., Professor of Natural History in Madison University, Hamilton, N. Y. 1 vol. 8vo, with 36 Illustrations and 2 Maps. London: John Murray. 1868.

The life of such a man in many senses resembles our own, but he experiences greater extremes of physical enjoyment and privation, of mental suffering and delight; and one of his chief advantages over us is the lasting pleasure which must remain when he returns to civilized life and subsides into the useful member of a family, the occupant of a cherished home. Then the remembrance of his exciting dangers abroad must afford him as much satisfaction as that of his most enjoyable hours. As he walks through the market, and his glance falls upon a tropical fruit, his mind must wander back to the virgin forest where he plucked it fresh and luscious from the tree; or as he inspects the treasures of some modest museum, and a rare creature, of which nothing but the skin is a reality, meets his eye, he starts for an instant, as he remembers with what surprise he first saw that form, here inanimate and perhaps disfigured by the dust of years, spring past him instinct with life as he wandered along the forest path, and disappear in the jungle before he had time even to raise his fowling-piece or rifle. Under the shade full of birds standing on the chimneypiece of some labourer's cottage, he espies in every little bright-winged creature a reminiscence of some new locality which he visited in times gone by; and whilst we should associate such objects with the auction mart, and estimate how many shillings the collection may have cost, he sees, perhaps, in one of the little feathered forms alone, the type of one which necessitated a whole day's pursuit and an unusual expenditure of his limited means. How thankful should we be to those enterprising and adventurous traders who bring into our parlours, boudoirs, and cottages the rarest and loveliest productions of tropical climes, and enable us to possess them for an outlay in some cases less than is requisite to obtain them where they are produced by nature.*

Nor must it be supposed that the roving naturalist passes through one continued series of privations all the year round, or lives in clover only when his gun supplies him with a superabundance of game; where he wanders, civilized men are often few and far between, and wherever the traveller appears, he brings to the colonist, what is more precious than gold or jewels, the sound of a cultivated voice, the recollection of home and friends far away; and no wonder that he is now and then a little petted and spoiled.

Mr. Wallace thus describes his life in Celebes:†—

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* Mr. Wallace tells us (vol. i., p. 473) that "numbers of the handsome but very common cones, cowries, and olives" (shells) "sold in the streets of London for a penny each" are natives of Amboyna, "where they cannot be bought so cheaply."

† Wallace, vol. i., pp. 362–3.

"My host Mr. M. enjoyed a thoroughly country life, depending almost entirely on his gun and dogs to supply his table. Wild pigs of large size were very plentiful, and he generally got one or two a-week, besides deer occasionally, and abundance of jungle-fowl, hornbills, and great fruit pigeons. His buffaloes supplied plenty of milk, from which he made his own butter; he grew his own rice and coffee, and had ducks, fowls, and their eggs in profusion. His palm-trees supplied him all the year round with 'sagueir,' which takes the place of beer; and the sugar made from them is an excellent sweetmeat. All the fine tropical vegetables and fruits were abundant in their season, and his cigars were made from tobacco of his own raising. He kindly sent me a bamboo of buffalo-milk every morning; it was as thick as cream, and required diluting with water to keep it fluid during the day. It mixes very well with tea and coffee, although it has a slight peculiar flavour, which after a time is not disagreeable. I also got as much sweet 'sagueir' as I liked to drink, and Mr. M. always sent me a piece of each pig he killed, which with fowls, eggs, and the birds we shot ourselves, and buffalo beef about once a fortnight, kept my larder sufficiently well supplied."

So much for the creature comforts, and now as regards the intellectual enjoyment which they accompanied. Our readers will not be surprised to hear that under the circumstances the author's pursuits as a naturalist were equally pleasant.

"I have rarely enjoyed myself more than during my residence here. As I sat taking my coffee at six in the morning, rare birds would often be seen on some tree close by, when I would hastily sally out in my slippers, and perhaps secure a prize I had been seeking after for weeks. The great hornbills of Celebes (*Buceros cassidix*) would often come with loud-flapping wings, and perch upon a lofty tree just in front of me; and the black baboon monkeys (*Cynopithecus nigrescens*) often stared down in astonishment at such an intrusion into their domains; while at night, herds of wild pigs roamed about the house, devouring refuse, and obliging us to put away everything eatable or breakable from our little cooking-house. A few minutes' search on the fallen trees around my house at sunrise and sunset would often produce me more beetles than I would meet with in a day's collecting, and odd moments could be made valuable which when living in villages or at a distance from the forest are inevitably wasted. Where the sugar-palms were dripping with sap, flies congregated in immense numbers, and it was by spending half-an-hour at these when I had the time to spare that I obtained the finest and most remarkable collection of this group of insects that I have ever made.

"Then what delightful hours I passed wandering up and down the dry river-courses, full of water-holes and rocks and fallen trees, and overshadowed by magnificent vegetation! I soon got to know every hole and rock and stump, and came up to each with cautious step and bated breath to see what treasures it would produce."*

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* Wallace, vol. i., pp. 364–5.

But the path of the naturalist traveller is not always so smooth: sometimes he is obliged to drag his weary body through marsh and morass, harassed by all kinds of tropical pests and encompassed by hidden dangers.

"When I reached Suban again," says Mr Bickmore,* "I felt a peculiar smarting and itching sensation at the ankles, and found my stockings red with blood. Turning them down I found both ankles perfectly fringed with blood-suckers, some of which had filled themselves until they seemed ready to burst. One had even crawled down to my foot and made an incision which allowed the blood to pour out through my canvas shoe. All this day we have suffered from these disgusting pests, our horses became quite striped with their own blood, and a dog that followed us looked as if he had run through a pool of clotted gore before we reached the highway again. Of all the pests I have experienced in the Tropics, or in any land, whether mosquitoes, blackflies, ants, snakes, or viler vermin, these are most annoying and disgusting."

And Mr. Wallace tells us† how, when the rains began at Celebes, "numbers of huge millipedes, as thick as one's finger and eight or ten inches long, crawled about everywhere, in the paths, on trees, about the houses;" and how he found, on rising one morning, that he had had one of them for a bedfellow!

In regard to trials and dangers, both travellers have their stories to narrate. Mr. Wallace tells his in modest and unaffected language and without any pretensions to heroism, whilst Mr. Bickmore uses such incidents for book-making purposes; and according to his own account, the Professor of Natural History at Madison University must have been as courageous as he was gallant, for whilst the terrible monsters of the animal kingdom fell beneath the blows of his axe, and his coolness was the admiration of the native men, we have the blushing confession that he was singled out by the dark beauties as the favoured object of their "osculatory salutes." But it is quite obvious to any one who has read the two works with care that the author who lays claim to the greatest coolness and courage, in reality experienced less opportunities for the exercise of either faculty: as to the osculatory business, we doubt not that the dark beauties *did* exhibit their good taste, and for the reason assigned by Mr. Bickmore, namely, as "they might never again have the privilege of kissing a gentleman with a white face."‡ The contrast between the style of the two writers is best seen in the description given by each of them, of an adventure he had with a python. Mr. Wallace discovered his snake in the roof within a yard of his head.

"He was compactly coiled up in a kind of knot; and I could detect his head and his bright eyes in the very centre of the folds. The noise of the evening before was now explained. A python had climbed up one of the posts of the house, and had made his way under the thatch within a yard of my head, taking up a comfortable position in the roof—and I had slept soundly all night directly under him.

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* Bickmore, pp. 492–3.

† Wallace, vol. i., p. 376.

‡ Bickmore, p. 193.

"I called to my two boys who were skinning birds below, and said, 'Here's a big snake in the roof;' but as soon as I had shown it to them they rushed out of the house and begged me to come out directly. Finding they were too much afraid to do anything, we called some of the labourers in the plantation, and soon had half-a-dozen men in consultation outside. One of these, a native of Bouru, where there are a great many snakes, said he would get him out, and proceeded to work in a business-like manner. He made a strong noose of rattan, and with a long pole in the other hand poked at the snake, which then began slowly to uncoil itself. He then managed to slip the noose over its head, and getting it well on to the body dragged the animal down. There was a great scuffle as the snake coiled round the chairs and posts to resist his enemy, but at length the man caught hold of its tail, rushed out of the house (running so quick that the creature seemed quite confounded), and tried to strike its head against a tree. He missed however, and let go, and the snake got close under a dead trunk. It was again poked out, and again the Bouru man caught hold of its tail, and running away quickly dashed its head with a swing against a tree, and it was then easily killed with a hatchet. It was about twelve feet long and very thick, capable of doing much mischief and of swallowing a dog or a child." *

Mr. Bickmore's python story is reserved as the crowning sensation, the *bonne-bouche*, of his work. This snake did not come upon him unawares; he had it presented to him in a cage, from which it escaped, and on searching for it, he found it coiled up in the ship's boat, on the deck of the vessel in which he was sailing. According to his account, all about him were cowards, he alone a hero; and the story of the death-struggle, though intended to be thrilling, is amusing in the extreme. It is illustrated by a plate, in which the hero is figured, apparently in his night costume (but that is explained), wielding an axe, and the fierce monster, with extended jaws, is about to dart upon him, whilst nine sailors and officers are looking on as unconcernedly as though they were witnessing a game of billiards. To add to the horror of the tale, "the first mate armed himself with a revolver," and every moment the hero expected to hear a report, and find himself shot by some of the braves behind him! "I felt the blood chill in my veins as for an instant we glanced at each other's eyes, and both instinctively realized that one of us two must die on the spot."†

Strange biological phenomenon! Here we have the sudden chilling of the sanguineous fluid of a warm-blooded animal, bringing him into sympathy with a cold-blooded reptile, and enabling the two for an instant to appreciate each other's instinctive sensations.

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* Wallace, vol. i., p. 466.

† Bickmore, p. 541.

However, we must not harrow the feelings of our readers, and therefore conclude by stating that the hero was victorious, and not only survived to tell his own tale, but went on to China, "and passed through more continued dangers and yet greater hardships than in the East Indian Archipelago." We should be harsh critics if we concluded Mr. Bickmore's work in his own words, for it might leave an impression on the reader's mind that it has nothing to recommend it except his sensational adventures. For the sake of science, as well as his own, we would advise the author, if he publishes another work, to keep such matter distinct from the more sober details of his experience. The fact is, that he spent a year very comfortably in the Dutch settlements of the Archipelago, possessing ample means for the attainment of his object, which was to make a collection of shells. He carried letters of introduction from his Government to the leading authorities, and usually travelled with an armed escort. He appears to have been no sportsman, although there are one or two passages in his work which would lead his readers to think the contrary, and almost always secured his game with a silver bullet. The headings of his pages are often sensational, as—"Among the Cannibals;"* "Riding along the Edge of a Precipice;"† "Among Tigers;"‡ "We come upon an Elephant;"§ "The Head-hunters of Ceram;"‖ All these horrors (excepting the "precipice," which resembles one of those winding roads round a marine cliff which our readers have, no doubt, frequently met with nearer home than Java, and the "Head-hunters," of whom "the Resident kindly" sent to invite a few to dance before him, as we see Kaffirs dance at Wombwell's menagerie) were only heard of by the author,¶ and it would have been better to reserve them for a Christmas story for boys, as an eminent African traveller has recently done, and in which they would have shone to more advantage than in a scientific work, the value of which depends upon its trustworthiness.

But whilst we feel bound, in the interests of science, to censure Mr. Bickmore's sensational statements of facts, and in that of literature, to draw attention to his Yankee phraseology, as when he speaks of what he saw "back of the village," and tells us that children "help support their parents;" or that he stood "half querying;" in consequence of which imperfections his book is *not* "quite all a European palate could desire," we still tender to him our thanks for his valuable contribution to our hitherto imperfect knowledge of the Malay Archipelago, and to the publisher, for the admirable illustrations, many of them from photographs, with which the work is enriched.

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* Bickmore, p. 125. † P. 419. ‡ P. 515. § P. 513. ‖ P. 203.

¶ A "head-hunter," along with one of the beautiful palms, the "Penang, or Betel-nut Palm," which illustrate Mr. Bickmore's work, have been introduced by our artist into his vignette. Mr. Wallace, we may here observe, slept in a Dyak-hut in Borneo, "very comfortably with half-a-dozen smoke-dried human skulls suspended over his head."

His account of some of the natural productions of the Archipelago is interesting; indeed, so far as those are concerned whose intrinsic value in civilized life is the greatest, such as sugar, with its manufacturing processes,* nutmeg and mace,† camphor,‡ his information is full and valuable. His description of the various fruits and trees is also exceedingly interesting; and the reader is enabled to appreciate the beauty of the latter through the well-executed plates already referred to. A comparison of his account of the curious fruit of the Durian (*Durio Zibethinus*) § with that of Mr. Wallace ‖ illustrates in an amusing manner the diversity of human tastes; and, as the fruit has scarcely ever been mentioned in England, it may be briefly noticed here. The "Durian" is a large spherical fruit, covered with sharply-pointed tubercles and a hard shell. Within, it is divided into several parts, and (according to Bickmore) it contains "a pale yellow substance of the consistency of thick cream, and having an odour of putrid animal matter, so strong that a single fruit is enough to infect the air of a whole house." The taste is described as similar to "fresh cream and filberts," but the odour was such as to repel the American traveller. Our own countryman describes the fruit in similar terms, and says "it smells like rotten onions;" but then bursting into a song in praise of its taste, which, he says, "resembles custard highly flavoured with almonds," but "intermingled with wafts of flavour that call to mind cream cheese, onion sauce, brown sherry, and other incongruities" (!) he tells us that he was a confirmed Durian eater, and, although Europeans cannot bear the fruit, and Mr. Wallace possessed his taste only in common with the savages amongst whom he lived so long, he considers it would be "worth a voyage to the East to experience the new sensation of eating it." Verily there is no accounting for tastes, and we should not be surprised if our author, or some one endowed with similar proclivities, were to tell us that he considers it worth while enduring all the hardships of a Russian winter to taste fresh caviare in Astrachan!

But Mr. Wallace has also some peculiar metaphysical theories concerning this strange fruit, for it furnishes him with evidence against the argument from design.

> "The Durian is, however, sometimes dangerous. When the fruit begins to ripen it falls daily and almost hourly, and accidents not

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* Bickmore, pp. 68 to 70. † Pp. 222-3. ‡ P. 433. § P. 91.

‖ Wallace, vol. i., p. 118.

unfrequently happen to persons walking or working under the trees. When a Durian strikes a man in its fall it produces a dreadful wound, the strong spines tearing open the flesh, while the blow itself is very heavy; but from this very circumstance death rarely ensues, the copious effusion of blood preventing the inflammation which might otherwise take place. A Dyak chief informed me that he had been struck down by a Durian falling on his head, which he thought would certainly have caused his death, yet he recovered in a very short time.

"Poets and moralists, judging from our English trees and fruits, have thought that small fruits always grew on lofty trees, so that their fall should be harmless to man, while the large ones trailed on the ground. Two of the largest and heaviest fruits known, however, the Brazil-nut fruit (*Bertholletia*) and Durian, grow on lofty forest trees, from which they fall as soon as they are ripe, and often wound or kill the native inhabitants. From this we may learn two things: first, not to draw general conclusions from a very partial view of nature; and secondly, that trees and fruits, no less than the varied productions of the animal kingdom, do not appear to be organized with exclusive reference to the use and convenience of man." *

With the first sentence in the author's closing remarks, namely, that we should not draw general conclusions from a very partial view of nature, we heartily concur; and this is precisely the error into which he and similar argumentators fall; but we should like to know who has ever been so foolish as to state that "trees and fruits, no less than the varied productions of the animal kingdom, *are* organized with *exclusive* reference to the use and convenience of man." We certainly do not remember ever having seen such a doctrine propounded, either by poet or moralist; but if we found such a position assumed, we should certainly not adduce the author's illustration as evidence against its validity. As well might he say that because fowling-pieces sometimes kill sportsmen who are foolish enough to get into the way when they are going off, therefore fowling-pieces were not designed for the exclusive use of Man!

But, on the other hand, if we wish for a mass of evidence in favour of design, before which Paley pales, we need only read the author's account of the Bamboo and its uses, which follows immediately upon that of the Durian. He shows that it is indispensable to the natives. Looking at their mental condition, they could not have existed without it, or some similar boon of Providence. Page after page of the work is occupied with an account of its uses. Every fraction of it is utilized. It enters into the constitution of their dwellings, serves as the raw material from which they make hen-coops, cages, fish-traps, bridges, aqueducts, water-buckets, cooking utensils, preserve jars, dagger-sheaths, pipes, cords, &c.; and yet he says:* "It is probable that my limited means of observation did not make me acquainted with one half the ways in which it is serviceable to the Dyaks of Sarawak."

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* Wallace, vol. i., pp. 119–20.

But upon what principle is this wonderful adaptation of means to ends explicable? The author gives us no clue to the mystery, *his* philosophy being merely negative. Does pure Darwinism account for it? Is it the survival of the fittest by means of natural selection? That is to say, has nature selected the fittest plant for Man's use, and allowed it to survive? No, that is not Mr. Darwin's theory. According to his view, which is no doubt correct as far as it goes, those forms of life survive which are the best able to resist adverse conditions of existence; and therefore, although the presence of the Bamboo in Borneo may help us to understand why Man has survived there, superseding perhaps some Simian form of life, yet it throws no light upon the adaptability of the vegetable to the wants of an animal (Man) not yet formed, whilst it was struggling with the surrounding conditions of existence.

Shall we gain a clue to the mystery by calling in the aid of the Huxleyan doctrine of "Matter and Law?" Wiser brains than ours may be able to apply that misty-physical philosophy, as recently enunciated by its author in a contemporary; † but we are constrained to admit that we do not yet clearly comprehend it, and are therefore unable to apply it in the case under consideration. "Matter," no doubt, there is—that is quite clear; and "Law," no one can ignore; but our difficulty is to ascertain whether in the case under consideration it is matter that legislates, or the law that is material; and we confess we have given it up in despair, for, after all, the whole phenomenon may be but "the unknown and hypothetical cause of states of our own consciousness;" and then of course it would be best to follow Professor Huxley's "wise advice," and "not trouble ourselves about matters of which, however important they may be, we know nothing, and can know nothing."

Well, then, as Darwinism fails to explain the phenomenon, and Huxleyism declines to come to our aid, we must, at the risk of being ranked amongst the superstitious, appeal to a very old-fashioned doctrine to account for the wonderful adaptability of every part of this beautiful tropical plant to the necessities and luxuries of what would otherwise be helpless human beings; and perhaps we may be permitted to cling for a little while longer to the delusion that a beneficent Deity, to whom there is no past nor future, does exist, and that it is He who, in ages long past, provided thus bountifully for the wants of His children still uncreated! We hope, notwithstanding the author's remark which has led to these reflections, that we have his assent to our views and inference.

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* Wallace, p. 126.

† The 'Fortnightly,' edited by John Morley, No. xxvi., Feb., 1861, in which the curious will find the latest exposition of the Materialistic doctrine, by one of its ablest professors.

LET not our readers, however, for an instant suppose that because we have grouped the two works before us under one heading, we therefore consider them to possess equal merit or scientific value. It happens that they have appeared about the same time, and treat of the same region of which little is known in civilized Europe; but Mr. Bickmore, who is an American Professor of Natural History, spent only twelve months in the Malay Archipelago, confining his visits and observations to the Dutch possessions there, and occupied himself chiefly in purchasing valuable shells from the natives; whilst our own countrymen, to whose work we now propose to direct special attention, resided in the Archipelago about eight years, during which period he visited and studied the physical geography and natural history of all the most important islands, including Borneo, Sumatra, Java, Bali, Lombok, Celebes, the Moluccas, New Guinea, with the surrounding islands, and the Malay Peninsula. Indeed, Mr. Wallace's book, which has long been expected by naturalists, is likely to be the standard work on those regions. The author, as most people are aware, is, so to speak, the originator of that view which Mr. Darwin (to whom his book is dedicated) has developed into a well-defined theory—the theory of Natural Selection; and although, in his published works, Mr. Darwin has traversed a wider range of Physical Science, and deals with more extended areas of the earth's surface than the author, yet we believe that the present work will be found to exercise a more potent influence, in the promulgation of the advanced theory, than the well-known treatises which have been published from time to time by the able writer whose name it bears.

For Mr. Wallace himself observed the phenomena which suggested to his mind the theory of natural selection; and although he seldom refers to that theory, and then only as though he were a modest disciple of Mr. Darwin, he brings those phenomena vividly before his readers; and the previous works of the last-named author having borne down prejudices and removed obstructions, the readers of the present treatise will be better prepared to accept the conclusions to which its numerous and well-recorded facts unquestionably point. The author's theory (one that has been floating in the public mind for some time) is that the continent of Asia at one period extended much farther eastward, and that of Australia farther west, than at present, until they almost joined, and that the two continents were probably separated by the Lombok Strait, which divides an island of that name supposed to have formed part of Australia from Bali, another existing island which is believed to have constituted, along with Java and Sumatra, a portion of the old Asiatic continent. This hypothesis is kept before the reader throughout the work, and is supported by all the data which can be furnished by physical geography, zoology, botany, and the heterogeneous nature of the inhabitants of the Archipelago. A shallow sea surrounds the *Indo*-Malayan region, as the author calls it, embracing the Malay peninsula, Sumatra, Borneo, Java, and Bali: another shallow sea encloses the Papuan region, whilst a deep one embraces the islands of Celebes, Lombok, Sumbawa, Flores, Timor, and the Moluccas—all of which together constitute the *Austro*-Malayan region. These conditions are well shown in the map which accompanies the work.

The fauna of Australia seems to have crept as far as Lombok; that of Asia to Bali; and in the passage from one island to the other, or rather by the contrast between the natural productions of the two islands, the author seems to have been led to adopt the theory which is so ably expounded in his work. When he first visited Lombok, the most westerly of the Austro-Malayan Islands, he says:—

> "Birds were plentiful and very interesting, and I now saw for the first time many Australian forms that are quite absent from the islands westward. Small white cockatoos were abundant, and their loud screams, conspicuous white colour, and pretty yellow crests, rendered them a very important feature in the landscape. This is the most westerly point on the globe where any of the family are to be found. Some small honeysuckers of the genus *Ptilotis*, and the strange mound-maker (*Megapodius gouldii*), are also here first met with on the traveller's journey eastward."

Subsequently he shows in detail how the Flora and Fauna of the Timor group—namely, Lombok, Flores, and Timor—represent the transition from the Asiatic to the Australian types. Thus there are—

	In Lombok.	In Flores.	In Timor.*
Javan birds	33	23	11
Australian birds	4	5	10

these islands being all separated from each other by a deep sea; and as the same rule applies in a greater or lesser degree to mammals, insects, and plants, the natural inference is, that the islands must at some time have been connected together; and, although he does not believe that Timor was actually connected with Australia in recent geological epochs, he considers that they were in much closer proximity than at present.

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* Wallace, vol. i., p. 320.

The human inhabitants of the Polynesian Archipelago, the author thinks, did not penetrate so far east as Lombok, and he draws the line between the Malayan and Polynesian races through the Sapy strait between the islands of Sumbawa and Flores, and northward through the Moluccas. This line of demarcation is shown upon another of the numerous maps which accompany the work.

To treat the subject with anything like particularity in this place would, however, be impossible, and for a full exposition of the author's views and theories we must refer our readers to the work itself, where they will find page after page of evidence to support them.*

And now what shall we say of the book, as the production of a naturalist and traveller? We think few will disagree with us when we pronounce it to be one of the most attractive and, at the same time, the most learned work on foreign travel, "with studies of man and nature," that has appeared in our language. It surpasses in scientific interest Mr. Darwin's Naturalist's Voyage in the 'Beagle' (and that is saying a great deal), because its author has been a more industrious observer and collector, and has been able to render it more attractive by the employment of modern methods of illustration; for these latter carry us into the heart of the remote and little-known regions which he visited, and enable us to form a good idea of their varied inhabitants of all kinds.† His collection "comprised nearly 3000 birds' skins of about 1000 species, and at least 20,000 beetles and butterflies of about 7000 species, besides some quadrupeds and land shells." ‡

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* The following is an extract from the 'Proceedings of the Royal Society,' No. cvi., Nov., 1868:—"A Royal Medal has been awarded to Mr. Alfred Russell Wallace, in recognition of the value of his many contributions to theoretical and practical zoology, among which his discussion of the conditions which have determined the distribution of animals in the Malay Archipelago (in a paper on the zoological geography of that region, published in the 'Proceedings of the Linnean Society' for 1859) occupies a prominent place.

"The case may be briefly stated thus:—The strait separating the islands of Baly and Lombok is only 15 miles wide; nevertheless the animal inhabitants of the islands are widely different, the fauna of the western island being substantially Indian, that of the eastern as distinctly Australian.

"Mr. Wallace has described, in a far more definite and complete manner than any previous observer, the physical and biological characters of the two regions which come into contact in the Malay Archipelago; he has given an exceedingly ingenious and probable solution of the difficulties of the problem, while his method of discussing it may serve as a model to future workers in the same field."

† In the second vignette, our artist has copied a portion of one of Mr. Wallace's plates, exhibiting the mode in which the natives shoot the Great Bird of Paradise.

‡ Wallace: Preface.

Nothing seems to have escaped his observation. The peculiar ways of the Chinese trader of Singapore amused him exceedingly.

"The shopkeeper is very good-natured; he will show you everything he has, and does not seem to mind if you buy nothing. He bates a little, but not so much as the Klings, who almost always ask twice what they are willing to take. If you buy a few things of him, he will speak to you afterwards every time you pass his shop, asking you to walk in and sit down, or take a cup of tea, and you wonder how he can get a living where so many sell the same trifling articles." *

We have met with something like this spirit in small continental towns. Then come the habits of the animal next below man in anatomical structure which he captured—the Orang-Utan. For that creature, by the way, he showed less sympathy than might have been expected in a Darwinian, for he appears to us to have shot it somewhat wantonly. The Dyak music made a great impression upon him, but we cannot say that we admire his taste in that respect. The association of art with savage life struck him as being sometimes very remarkable. At Dorey, in New Guinea, he found the worst savages whom he anywhere met with, and after describing their habits, he says: "If these people are not savages, where shall we find any? Yet they have all a decided love for the fine arts, and spend their leisure time in executing works whose good taste and elegance would be admired in our Schools of Design!" † This is the first step towards human culture, and it carries our minds back involuntarily to those periods in human history when rude outlines of animals, now extinct, were carved on knife and axe handles; but there are in those wonderful eastern islands traces of a civilization far different from this. In Java there exist vast piles of ruined temples, covering miles of ground; and in one spot "traces of nearly 400 temples have been found," ‡ whilst "the ruins of forts, palaces, baths, aqueducts, and temples can be everywhere traced."

The numerous and beautiful tropical plants, with their luscious fruits and varied uses, and all the denizens of the animal kingdom, come under the author's notice, as we have already seen; especially interesting is the account of the exquisite birds of Paradise, to obtain which he sacrificed health, strength, and almost life itself. Nor are the grander phenomena of nature, such as earthquakes and volcanoes, overlooked in the naturalist's zeal. Of those he speaks without exaggeration, whilst he seeks at the same time to convey to the reader's mind the stupendous changes which the occult forces of nature have brought about upon the earth's surface; and to them he largely attributes the physical configuration of the land, and the

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* Wallace, vol. i., p. 33. † Vol. ii., p. 325. ‡ Vol. i., p. 166.

past and present geographical relations of the various islands which he visited. Political and social economy, good and evil government are discussed; and although the author is not likely to find many disciples in his advocacy of monopoly abroad and protection at home, yet the facts noted by him even on these subjects are well worthy of the consideration of practical minds. The great charm of the work is its obvious truthfulness and simplicity, and if the author sometimes misses opportunities (of which travellers usually avail themselves with such eagerness) of appealing to the sense of wonder in his readers, he inspires, on the other hand, the most implicit confidence in all he says, and often affords us some consolation for having to read about, rather than participate in his adventures.

After describing some of the beautiful scenery of Mount Ophir, in the Malay Peninsula, he concludes his account of it by saying:—"The top is a small rocky platform covered with Rhododendrons and other shrubs. The afternoon was clear and the view fine in its way—ranges of hill and valley everywhere covered with interminable forest, with glistening rivers winding among them. In a distant view a forest country is very monotonous, and no mountain I have ever ascended in the tropics presents a panorama equal to that from Snowdon, while the views in Switzerland are immeasurably superior."* Some satisfaction, this, to the tourist at home, whose means or opportunities will not allow him to visit the tropics.

Again, let us recommend the romantic enthusiast who longs to visit the court of an Eastern Rajah, and catch a glimpse of the beauties who inhabit the Harem, to pause and ascertain the author's experience in that way. He had an interview with a "Rajah," the Queen and her daughters, and concerning the latter he says:—

> "And here I might (if I followed the example of most travellers) launch out into a glowing description of the charms of these damsels, the elegant costumes they wore, and the gold and silver ornaments with which they were adorned. The jacket, or body of purple gauze, would figure well in such a description, allowing the heaving bosom to be seen beneath it, while 'sparkling eyes,' and 'jetty tresses,' and 'tiny feet,' might be thrown in profusely. But, alas! regard for truth will not permit me to expatiate too admiringly on such topics, determined as I am to give as far as I can a true picture of the people and places I visit. The princesses were, it is true, sufficiently good-looking, yet neither their persons nor their garments had that appearance of freshness and cleanliness without which no other charms can be contemplated with pleasure. Everything had a dingy and faded appearance, very disagreeable and unroyal to a European eye."†

And, finally, it will be pleasing to our countrymen to hear that if the gigantic vegetation of the tropics has so long formed the theme of the traveller's admiration, we have in our English scenery a feature largely wanting in the tropical world, which more than compensates for the absence of Palms, Tree Ferns, and gigantic Fig-trees, namely, the masses of flowers which adorn our landscapes. After describing such scenery as can only be met with where nature has been most lavish of her tropical gifts, Mr. Wallace says:*—

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* Wallace, vol., i. p. 50.

† Pp. 343-4.

> "The reader who is familiar with tropical nature only through the medium of books and botanical gardens, will picture to himself in such a spot many other natural beauties. He will think that I have unaccountably forgotten to mention the brilliant flowers, which, in gorgeous masses of crimson, gold, or azure, must spangle these verdant precipices, hang over the cascade, and adorn the margin of the mountain stream. But what is the reality? In vain did I gaze over these vast walls of verdure, among the pendant creepers and bushy shrubs, all around the cascade, on the river's bank, or in the deep caverns and gloomy fissures,—not one single spot of bright colour could be seen, not one single tree or bush or creeper bore a flower sufficiently conspicuous to form an object in the landscape."

This peculiarity he explains by stating that it is the custom of travellers to have their attention drawn to the few rare and magnificent flowers which are here and there met with in hot climates, and are gathered together and fostered with so much care in our conservatories at home; but he adds, "During twelve years spent amid the grandest tropical vegetation, I have seen nothing comparable to the effect produced in our landscapes by gorse, broom, heather, wild hyacinths, hawthorn, purple orchises, and buttercups."†

And now, in conclusion, let us express the hope that in thus seeking to treat Mr. Wallace's work with impartiality, and to show how unprejudiced he usually is in his judgments, we may not have detracted from his merits as a literary man, nor yet from his work as an interesting record of a traveller's experiences. We might have selected far more "telling" passages for extracts than we have done, and perhaps thus have enabled the publishers to sell a few more copies of the work at the outset. But that is quite unnecessary. It will bear its own recommendation in its pages, and we have felt it our duty to place upon it, as far as we are able, the stamp of scientific authority, where there are so many scientific novels running their ephemeral course, so that every intelligent man who thinks fit to give it a permanent place upon his shelves may feel assured that he is depositing there for the benefit of posterity a highly valuable contribution to the scientific literature of our age.

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* Pp. 371–2.

† Wallace, vol. i., pp. 373.

II. THE PROJECTED MERSEY TUNNEL AND RAILWAY.

(From Liverpool to Birkenhead.)

By Sir Charles Fox.

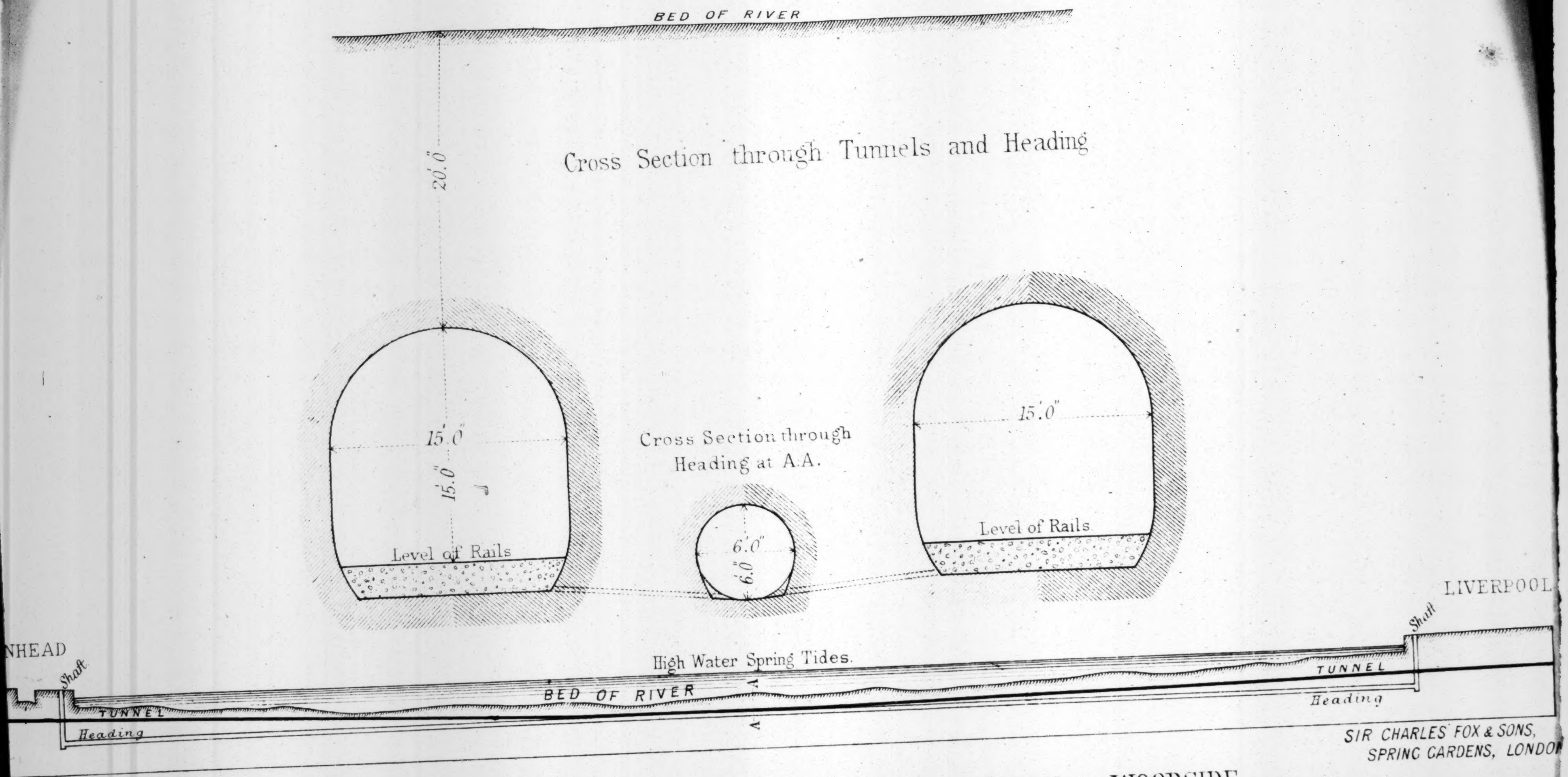
As a means of intercommunication between Liverpool and Birkenhead, a tunnel beneath the Mersey has been under consideration by leading men on both sides of the river for upwards of thirty-eight years; and when the inconvenience and loss both of time and money which the want of such a means of transit has ever occasioned are considered, it is, in these days of increased facilities, a matter of surprise that, while works of real difficulty have been carried to completion on every side, this obvious want should not have been satisfied.

There is but one opinion as to the importance of intercommunication between Liverpool and Birkenhead, and it being admitted that the great obstacle in the way of its realization is the doubt existing in the public mind as to the cost at which it can be attained, it has been felt that this doubt can never be overcome unless the nature of the river-bed is conclusively proved.

When this has been done, I am sure that the construction of a tunnel through the red sandstone rock under the Mersey will be found an easy and inexpensive operation, as, judging from the many similar works which have been executed in this rock during the last forty years (those most analogous having been tunnels of various dimensions carried on at considerable depth below the level of the bottom of the river, with a view of obtaining a more copious supply of water for the town of Liverpool), it has been ascertained that in no material can such works be effected at so small a cost as through the very strata now well known to exist in this locality, the amorphous nature of the rock rendering it peculiarly advantageous for tunnelling operations.

Tunnels have been made at a low price through chalk, as that material is readily excavated; but from its general looseness and its consequent tendency to fall, it is deemed necessary, for the purpose of ensuring safety, to put in brick or stone lining, and this, as compared with red sandstone, which generally requires no such lining, considerably augments the cost; and it must not be forgotten that the sandstone, when excavated from a tunnel in or near a town, is saleable for use as building material; while chalk, taken from a tunnel, being of no value, is more generally run to spoil.

It would appear that one of the most formidable hindrances in the way of getting capitalists to embark their money in making tunnels under rivers, of which very many are urgently needed,



SIR CHARLES FOX & SONS,
SPRING GARDENS, LONDO

& Sons, Lith

PROPOSED TUNNEL UNDER THE RIVER MERSEY FROM LIVERPOOL TO WOODSIDE.

arises from the disposition which undoubtedly exists to form an unfair comparison between such works and the Thames Tunnel, which, as every one conversant with the circumstances connected with it will know, cost a very large sum, although passing under a river of no considerable breadth. This, however, is no fair criterion upon which to judge of any other case. This tunnel was constructed some forty years since, when the science of tunnel-making was but little understood, and when it had to be applied upon a very limited scale, without the advantages arising from many later improvements, and without the extensive experience derived during the last forty years from works of this nature, required in the development of the railway system all over the world.

This makes a comparison deceptive, to say nothing of the Thames Tunnel having to be constructed under all the difficulties of passing, not through London clay, which it would have done had it been placed a few feet deeper, but through the treacherous and loose silt and gravel of the bed of the river Thames, while the tunnel which forms the subject of this paper will pass through solid rock.

To attempt to draw a comparison between this project and the Thames Tunnel is but to show an entire want of acquaintance with the relative circumstances of the two cases, for it must be borne in mind that the Act authorizing the construction of the latter received the Royal Assent on June 24th, 1824, more than forty-four years since, and that the tunnel was not opened for passenger traffic till March 25th, 1843, having occupied a period of eighteen years and three-quarters in arriving at completion.

Were this work now taken in hand by an Engineer possessing the experience obtained in constructing tunnels since the period above referred to, taking care to place his work deep enough to let it pierce only the London clay (to have done which the present tunnel ought to be fifteen feet deeper than it is), no doubt the entire work could be completed for little more than a tithe of the cost (which was 454,700*l.*), and need not certainly occupy a longer period than two years, as is proved by the following facts:—

The excavation for the Thames Tunnel commenced in December, 1825, and all went on satisfactorily until 12th May, 1827, when, the upper portion of the works protruding above the London clay into the gravel and silt of the bed of the river, the first irruption of water took place, there being then a length of 545 feet of the tunnel constructed, which had been done in a period of seventeen months; so that, had no casualty occurred, and assuming that the rate of progress was not, as it no doubt would have been, augmented by the natural increase which always follows a better knowledge of any work, the whole 1200 feet would have been completed within three years and two months; and this, be it remembered, would have been the result if made wholly from one end; whereas, with the present increased facilities and knowledge of the operation, it would have been carried on from both sides simultaneously, when, even at the then slow rate of progress, the time would be reduced to one year and seven months; so that there can be no doubt that, with present appliances, the work of the tunnel could, with perfect ease, be completed in one year and a quarter; and taking for the shafts and other matters, say, half a year more, the whole could with convenience be accomplished in one year and three-quarters.

In order to clear up every doubt, I propose, at an estimated cost of 20,000*l.*, to drive a heading under the Mersey from shore to shore, a distance of 1300 yards, and thus not only to prove the practicable nature of the larger and more complete undertaking, but also the future cost, whilst at the same time providing the necessary drainage and ventilation for the permanent works.

The first operation will be to sink a shaft on either side of the river, on land belonging to the Mersey Docks Board, to a depth of about 120 feet below the surface (see Plate, lower figure). The shaft on the Liverpool side will, for a depth of say 40 feet, pass through made ground, and will then enter, and for the remainder of its length be entirely through, the solid rock. That on the Birkenhead side will be in solid rock throughout. These shafts will be about 10 feet in diameter, and will terminate in large sumps for pumping purposes. At each will be erected permanent pumping engines and pumps of sufficient power to deal with the largest quantity of water that is likely to be met with, and which pumps will not only be used during the construction of the works, but be adapted for keeping the main tunnels permanently free from water. Winding engines will also be erected of sufficient power, not only to deal with the material excavated from the heading, but also with that from the tunnel itself.

The shafts having been sunk to the full depth, and the machinery fixed, the heading will be commenced from either end, and driven much in the same way as an ordinary mining water-level. It will have a very slight rise towards the middle of the river, so as to drain both ways into the shafts. Judging from experience, I expect that, at least, 4 yards lineal a day will be driven at either end, giving a total of 160 working days, or thereabouts, for the completion of the heading after the shafts are sunk. I have taken much pains to collect evidence as to the nature of the rock through which the heading will pass, and have found everyone conversant with the subject unanimous upon the point. The general result of my inquiries and observations cannot be more forcibly explained than by the following summary of evidence given before the Referees of the House of Commons in 1865.

The late Mr. Thomas Duncan, then Engineer to the Liverpool Waterworks, stated that he knew well the nature of the rock, which is not very porous. He did not think the quantity of water produced from the rock at Birkenhead and Liverpool would make the tunnel a difficult work of construction, and he did not believe there would be any difficulty in carrying it through so far as water is concerned. He considered that the "faults" existing in the sandstone rock, and shown on the geological map, were advantageous, as he had cut through many of them (having excavated in the red sandstone at various points over sixty square miles) and had nearly always found them filled up with a species of concrete, which was perfectly water-tight. In a few instances, however, he had found them filled with laminated rock, having a saccharine appearance, and evidently having been subjected to a great heat, and yet water-tight.

Mr. James Abernethy, C.E., stated that, having been Engineer to the Birkenhead Docks, he had large experience of the sandstone rock, and that the rock under the river is good hard red sandstone rock, of the same character as the rock excavated from the Birkenhead Docks, which is a close, compact, strong stone, suitable for building purposes.

Mr. John Fowler, C.E., stated that in framing his estimates he had well considered the question of possible faults in the rock, and, on the whole, preferred to have faults of the character known to exist in the red sandstone at Liverpool and Birkenhead, as they, being impervious to water, back up and limit in area the water contained in the interstices of the rock. The faults are filled either with clay or with some vitreous material. Mr. Fowler further stated that he considered red sandstone at all times the best material to construct tunnels through.

Besides the above testimony, there is the further fact that Mr. John Hawkshaw, C.E., F.R.S., proposes to construct a tunnel under the Mersey, near its mouth, where the river is very wide and the character of the rock less certain; and it is therefore evident that Engineers of eminence are agreed in considering the work of making a tunnel thoroughly practicable, and that at a moderate cost.

As much doubt has been expressed as to the possibility of driving the heading for any such sum as 20,000*l.*, I would remark that the Trustees have before them a tender from a responsible contractor, who is prepared to undertake to complete the work considerably within that amount, finding all necessary plant and machinery, and giving approved security to the extent of 5000*l.*

Again, the chief item in the cost of this work is that of excavation, and the Engineers already mentioned, and who gave evidence before the Referees, were agreed in considering 9*s.* a cubic yard an ample price for this work in the tunnel, including all possible contingencies, being, in fact, three times the cost of similar work under ordinary circumstances. I have, however, taken 20*s.* per cubic yard for the excavation in the heading, which I believe to be far more than it can cost.

That a tunnel, or as it is called, a subway, can in the estimation of those competent to form an opinion, be carried under the river Thames at a very small cost, is, I think, proved by the fact that Parliament, last session, passed an Act for the "Tower Subway," proposed by Mr. P. W. Barlow, F.R.S., C.E., son of the highly-talented Professor of mechanics of that name, the capital for which is but 12,000*l.*, with power to borrow 4000*l.*

This work is now in course of construction, and is to consist of an excavation through the London clay 440 yards in length, lined with cast-iron cylinders ⅞″ thick, with strengthened flanges, whose external diameter will be 7 · 1¾″, or 7 feet inside.

At each end there will be a vertical shaft between 50 and 60 feet deep, fitted with lifts for the purpose of raising or lowering passengers from and to a saloon carriage, which will at very frequent intervals pass through the heading for the conveyance of passengers.

From each end the subway will fall towards the centre of the river at an inclination of about 1 in 40 to a level under the river, where the rails will be at a depth of 61′ 6″ below Trinity high-water mark.

With regard to the above, it may no doubt be said that it is as yet only a matter of estimate; and though given by an Engineer of standing and approved by Parliamentary committees—one of whose special duties it is to investigate the estimates for the purpose of testifying to their sufficiency,—yet the estimate might prove fallacious. I now, therefore, proceed to give the cost of an important work at Chicago, completed some time since, and in many respects analogous to the one of which I am treating, but beset with some difficulty not to be encountered in passing under the Mersey, arising in great measure from the more uncertain material through which the heading had to be driven; that at Chicago being clay, and that at Liverpool red sandstone—the one being driven for two miles, or 3520 yards, under Lake Michigan, the other only 1300 yards under the river Mersey.

The Chicago tunnel was made by Mr. Chesbrough, C.E., Engineer to the municipality of Chicago, for the purpose of obtaining a more ample supply of pure water for the inhabitants of that important city from a point beyond the reach of sewage contamination; hence its great length.

This work, embracing as it does two miles of heading carried through clay, lined with two rings of brickwork, including a sum of $120,000 expended on the two shafts and the appliances connected therewith, cost $380,000, or 76,000*l.*

The above amount spread over the 3520 lineal yards of heading gives 21*l.* 11*s.* as the cost of each lineal yard, and deducting therefrom 7*l.*, the value of the additional excavation, centering, and brick-lining (not found necessary in tunnels in the red sandstone), it will bring the price per lineal yard to 14*l.* 11*s.*, without taking into account the more than double value of labour at Chicago, which has unfortunately greatly augmented the outlay upon this work.

Now 20,000*l.* expended upon 1300 lineal yards of heading under the Mersey gives the price for each 15*l.* 5*s.*, so that, in drawing a comparison between the two works, a greater sum has been taken in the estimate for the one than has been actually expended on the other, and this is assuming the price of labour to be the same in both instances, which, however, is by no means the case, that at Chicago being very high.

I may here allude to a very interesting and instructive work, also very analogous to that proposed under the Mersey, which has been carried to a satisfactory conclusion at Attock, on the Khyrabad Pass, in India.

It consists of a heading 600 yards long, 6 feet square, driven under the river Indus through a rock, which forms its bed, at a depth of somewhat over 90 feet below the surface of the flood-water.

It has been carried on by a few labourers, under the charge of Mr. Robinson, who have succeeded in filling up the fissures they met with during the operation by simple "feather" wedging of wood, and have by this expedient been able to keep back all the water which otherwise would have flowed into the heading with a force due to the whole superincumbent column.

The cost of this work has been about 13,000*l.*, and spreading the whole outlay over the 600 yards, brings out the cost to about 21*l.* 14*s.* per yard, which goes to prove that, had the labour expended upon it been paid for only at English prices, it would have been executed at a considerably smaller cost than that arrived at by estimate for making the heading under the Mersey.

I have lately constructed a water-level, nearly one-third of a mile long, through harder rock, yet far less compact and more broken up, having much larger feeders of water than any to be expected in the red sandstone. In driving this heading and the shafts connected therewith, single feeders were met with yielding 1,000,000 gallons per diem, yet these were dealt with without serious difficulty or expense, the cost not having been one-half that estimated for the Mersey work.

In driving the heading a boring-rod would, as is usual in water-bearing strata, be kept ahead of, and at the top of, the work, and thus due notice would at once be given of any unusual feeder of water, should such exist.

All ordinary cracks in the sandstone are readily made watertight by the use of a "feather" wedge of timber tightly driven into them. If a large crack were met with, containing water (a most unlikely thing, as has been already shown), a lining of iron would be put into the heading and pushed forward, as the excavation proceeded, until the fault was passed.

The heading will be circular, and 6 feet in diameter.* It will, when completed, be available not only for draining the tunnels, but for telegraphic purposes, and probably also for conveying water from the Welsh lakes to Liverpool, thus avoiding a lengthened détour and most expensive works.

The heading having been successfully driven, I am confident that there will be no difficulty in letting a contract for a double line of railway under the river Mersey for 100,000*l.*, which would, indeed, give a price of 77*l.* per lineal yard of tunnel—the work being through good hard sandstone and thoroughly drained by means of the heading; whereas 60*l.* a lineal yard is a large price for tunnels, even through clay, where, of course, heavy lining, including an invert, is required.

The river tunnel being completed, the remaining works necessary to bring the two towns of Liverpool and Birkenhead into complete communication with each other will be of a very ordinary kind, and free from any unusual contingency.

Under the existing Parliamentary powers, the railway can be completed in a direct line from Church Street, Liverpool, to Woodside, Birkenhead, with an intermediate station at the bottom of James Street, and by its means, and by trains running every few minutes, passengers will be conveyed between the termini in six minutes. The authorized line runs entirely either under the river or under streets, and not a single house will be taken for the railway itself, and only one or two for station purposes. The railway can be readily constructed without interference with the traffic of the streets. The main line will be double, with extensive sidings for goods, in direct communication with the dock lines on either side of the river.

Surveys have been completed of extensions, whereby the Mersey Railway can be made to form a direct connecting link between the important railway systems on either side of the river, and this at a moderate expense, and with the destruction of hardly any property.

The effect produced by the opening of this railway will be very great. The docks of Liverpool and Birkenhead, now under the same management, form the noblest emporium of trade in the world, but their joint usefulness is much impaired by the want of satisfactory communication between the two sides of the river; and the immense resources of Birkenhead, developed at a cost of nearly 7,000,000*l*. sterling for docks alone, are lying comparatively idle, whilst the quays and docks on the Liverpool side are flooded with a trade increasing daily, and already over-tasking their capabilities.

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* See Plate. It is unnecessary to give any detailed description of the Plate as it explains itself.

More dock and quay accommodation must be found. On the Liverpool side, to construct fresh docks either north or south, is to place them miles away from the centre of trade—at the north, in a very exposed situation, almost unapproachable in heavy weather, at the south, only available for vessels of comparatively small draught—what then so natural as to utilize the expenditure at Birkenhead, now yielding but a nominal return, but which, with the Mersey Railway completed, would be placed in a very different position. The Birkenhead docks and warehouses would then, as regards both passengers and goods, be placed within a few minutes, in all weathers, of the heart of Liverpool.

The immense traffic to be expected under such altered circumstances, may be inferred from the fact that, with the present imperfect means of communication, often brought almost to a standstill by a fog, or a gale of wind, twenty millions of passengers, at least, pass over the ferries annually.

The Cheshire side of the Mersey abounds with pleasing sites for residential purposes, and not only New Brighton, but many other places, would experience an immediate increase if railway communication were established. Thousands of persons who would prefer a residence on that side, are, at present, deterred by the difficulties of the daily crossing to their places of business.

The construction of this railway, and its extensions would, also, place Liverpool in direct communication with North Wales and Holyhead.

Liverpool, Birkenhead, and their surroundings now contain at least seven hundred thousand inhabitants, and the steady increase of population renders means of communication every day more urgent.

If this railway be not soon completed, an immense expenditure must be incurred to improve the approaches to the landing stages, which will, after all, not get rid of the most serious inconveniences connected with the ferries, which are chiefly caused by fogs and storms.

Those who have interested themselves in the Mersey Railway are in earnest in the matter, and if they meet with but moderate assistance from those locally concerned, Liverpool and Birkenhead will soon be connected by a direct railway.

III. VESUVIUS.

WHAT Baden-Baden is among inland watering-places, Brighton and Scarborough among marine resorts, Epsom among race-courses, such is Vesuvius among volcanoes. The Spaniard ardently exclaims, "*Que no ha vista Sevilla, no ha vista maravilla;*"* and truly this may be said of Vesuvius. It is, *par excellence*, the type of volcanoes, both for its historical interest, and the natural beauty of its surroundings.

That it should be so will seem quite natural when we reflect, that from its position, near the centre of the earliest and highest civilization of Europe, its spasmodic movements were anxiously watched, and more or less frequently recorded for nearly eighteen hundred years; sixty-six eruptions having been chronicled between A.D. 79 and 1868.

With the exception of its sister volcano Etna, there is no other burning mountain whose history can compare for a moment in interest or extent with that of Vesuvius; indeed only a very few out of the 225 recognized active volcanoes were known five hundred years ago.

Among the many scientific visitors who were attracted last year to "the City of the Siren" by the activity of Vesuvius was the veteran Professor Phillips, who for more than fifteen years has filled the Chair of Geology in the University of Oxford.

Accompanied by an early geological friend and most excellent antiquary, Mr. John Edward Lee, of Caerleon, Professor Phillips examined Vesuvius, and the result lies before us in the shape of a small and neat octavo volume,† illustrated by two maps, nine plates, and thirty-five diagram woodcuts, expressive, but rough, like the scoriæ, tuffs, and lavas they so well depict.

Another tourist to Vesuvius, Mr. J. Logan Lobley, F.G.S., has also put on record an account of his own observations in an unpretending little volume ‡ of fifty-five pages, accompanied by a view, a map, and a section of the mountain.

Isolated as we happily are in Britain from lands in which the subterranean energies of our earth still manifest themselves at the surface in the form of volcanic outbursts, it must not be supposed that our countrymen, who have for so long a time been foremost in all the other branches of cosmical science, should on this account have devoted but little attention to Plutonic investigations.

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* "Who has not seen Seville has not seen a marvel."—*Spanish adage.*

† 'Vesuvius,' by John Phillips, M.A., D.C.L., LL.D., F.R.S., &c., &c. Oxford: Clarendon Press. 8vo. 1869. Pp. 355.

‡ 'Mount Vesuvius: a Descriptive, Historical, and Geological Account of the Volcano, with a Notice of the Recent Eruption,' &c. By J. Logan Lobley, F.G.S. 8vo. 1868. London: E. Stanford.

On the contrary, we recall the writings of Sir W. Hamilton,[*] Professor Babbage,[†] Mr. G. Poulett Scrope,[‡] Dr. Daubeny,[§] Principal Forbes,[‖] Sir Charles Lyell,[¶] Charles Darwin,[**] and many others who have each contributed a share to the world's store of knowledge on volcanic phenomena, and largely to the history of Vesuvius itself.

Any book therefore which may now be written upon Vesuvius, must of necessity draw largely upon these already written histories, and its author must be likewise indebted to Padre Della Torre, Guiscardi, Monticelli, Palmieri, and other foreigners who have given special attention to this volcanic mountain.

Nor can any description of Vesuvius be complete which does not include the account given by Pliny the younger of the eruption of A.D. 79, in which the elder Pliny lost his life.[††] This eruption justly deserves the attention it has received of all subsequent historians, not only from the loss of the celebrated naturalist Pliny, but also because of the sudden overwhelming of those large and populous cities, Herculaneum, Pompeii, and Stabiæ, which at that time stood in the Campania on the shores of the Bay of Naples, and the exploration of whose buried streets and palaces has added so largely to our knowledge of the arts and civilization of the ancient Romans.

"Through eighteen centuries," writes Professor Phillips, "the dwellers round the Bay of Naples have watched with mingled pride, wonder, and alarm, the great solitary mountain whose shadow in the morning stretched across the sea, and whose evening splendour threw into far distance the snowy peaks of the Apennines.

"Well might they be proud of so fair a prospect. All around the mountain, and even climbing to half its height, stretch vineyards and orange-groves, populous towns and prosperous villages, churches, palaces, and ports; the well-paved road, and the Strada Ferrata. Here the Norman built his fortress, the Roman reared his amphitheatre; and long before the birth of Rome, the wandering Greek or Phœnician trader laid the foundations of Cumæ and Pæstrum, perhaps as long after an earlier race had built the giant walls of Arpinum and Alatrium, Ferentinum and Venafrum. Such has ever been this fertile land since history began to shed light on ancient Hesperia; a country on which the sun shines in his strength, washed by a translucent sea, bordered by the most picturesque shores in the world, and these crowned by villas and palaces, temples and tombs, of every age and many nations—worshippers of Neptune the earth-shaker, and believers in Januarius, whose very image stays the heaving of the ground and arrests the current of lava. Well might they wonder and be terrified! More than fifty times since the Christian era has the mountain poured forth floods of lava and tossed up clouds of ashes; while far more frequent tremblings of the earth have justified the fable of antiquity, that Titanic forces lay oppressed but struggling below the heavy load of the Phlegræan hills."

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[*] *Campi Phlegræi.* Fol. Naples, 1776.

[†] 'Geog. Proc.,' vol. ii. p. 72; and 9th 'Bridgewater Treatise,' p. 200.

[‡] Scrope, 'On Volcanoes,' 2nd edition, 1862.

[§] Daubeny, 'On Volcanoes,' 2nd edit., 1848; and QUART. JOURN. OF SCIENCE, vol. iii., p. 199.

[‖] Forbes, in Brewster's 'Edinburgh Journ.,' 1829, &c., vol. iv., p. 12; and 'Miscellanies,' vol. i., part 2.

[¶] Lyell's 'Principles.' 10th edit., vol. i., pp. 598–654.

[**] Darwin, 'On Volcanic Islands,' &c.

[††] *Plinius Cæcilius Secundus* (*Caius*) *to Cornelius Tacitus.* Book vi., Epistle xvi. and Epistle xx.

"Threatened people live long," and the inhabitants of *Campania felix*, who, amidst perpetual fertility, have to put up with occasional terrors and sometimes to witness the destruction of their homes and churches by the devouring lava-streams, cannot be induced to quit the dangerous but lovely spot.

Thus we find the modern and flourishing town of Resina standing on the ashes and lavas beneath which Herculaneum lies buried: and Torre del Greco even nearer to the mountain than Resina, and three or four times, more or less, destroyed by lava-streams, its total destruction being all but accomplished (but for St. Januarius) by the eruption of 1861.

It has been already mentioned that sixty-six eruptions are on record since A.D. 79. These, as matter of course, have not only altered the appearence of the surrounding country, but have frequently changed the form and height of the crater itself.

Seen from the sea or from the Campagna, Vesuvius rises alone from a broad base, and its outlines sweep upwards in an easy curve, growing continually bolder towards the summit, and these, in ordinary periods of tranquillity, passing over an uneven but variable "dome" or "cone" 4000 feet high, to slopes on the opposite face not tamely identical, but harmoniously diverse. The view from Naples eastwards is in happy contrast with the opposite one, the northern outline being broken by a deep hollow, which is itself overlooked by a sharp angular crest 3760 feet above the sea. Thus the mountain appears double: the northern crest is now called the "Monte Somma," the hollow is the "Atrio del Cavallo," and the dome-shaped summit, now the highest part of all the area, is the modern "Monte Vesuvio."

Viewed from the south-west in the direction of Sorrento or Capri, Vesuvius is in front, and its long continuous slope comes down to Pompeii on the south, and to the sea at Torre del Greco, and Resina on the west; while on the north it is encircled by the rugged crests of Somma.

The histories of Somma and Vesuvius, as known to us, are strikingly different. Somma, the broken external crest of the greater and earlier volcanic crater, has been unmoved in place, unchanged in form and height (save by atmospheric denudations) through eighteen centuries.

Vesuvius, born of Somma, and seated within the encircling grasp of its parent, is a variable heap, thrown up from time to time, and again, not seldom, by a greater effort of the same force, tossed away into the air, and scattered in clouds of dust over far away countries.

Thus it has happened often, in the course of these variations of energy, that Vesuvius has risen to a conical height exceeding that of Somma by 500 or 600 feet, and again the top has been truncated to a level as low as Somma, or even as much below that mountain as we now behold it above it.*

Within the last four hundred years the cone of Vesuvius has been five several times gutted by explosive eruptions of a paroxysmal character, *viz.* in 1794, 1822, 1831, 1839, and 1850; and its central craters formed in this manner as often gradually refilled with matter, to be again in due time blown into the air.

B.C. 72 Vesuvius was unborn; and the great crater of Somma, a mile in diameter, its summit encompassed on all sides—save one which had a narrow breach—with broken and slippery precipices covered with wild vines, reared its truncated cone in silent grandeur unbroken by the least fretful token of an eruption.

To this wild spot retreated Spartacus and his small army at the beginning of the Servile War, the floor of the crater being then a nearly level surface, but deeply sunk below the encircling walls.

It was, no doubt, the great eruption of A.D. 79 which blew away nearly three quarters of the crater-walls of Somma, beneath whose ponderous ruins the towns of Herculaneum, Pompeii, and Stabiæ lie buried; and to this day we trace in the platform of the Pedimentina the outline of the base of the south-western portion of the ancient Somma, although, of course, much obscured by modern lava-flows.

Meantime, what remains of the old external crater is itself becoming choked up by the accumulation of all the lava-streams and fragmentary matter that are expelled towards the northern and outer side of the cone, which is also growing in bulk all round. It would therefore be in exact accordance with the habit of this volcano (as of volcanic mountains in general), if at length the valley of the "Atrio," which at present separates the remains of the ancient and far larger cone of Somma from the modern cone of Vesuvius, should be completely filled up, the two cones combined into one, of increased height and bulk, and ultimately, perhaps, the entire conjoint mountain should be blown up by a more than ordinarily violent paroxysm, and the crater of Somma re-formed.*

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* Phillips, p. 174.

Although many of the early writers have preserved for us much of interest which relates to Vesuvius, yet their ideas of telluric phenomena were always so involved with the supernatural, that we are seldom able to reach the germ of truth which produced the great mass of mythological romance.†

Strabo, Vitruvius, Diodorus Siculus, and Tacitus, all speak of the indications of the igneous origin of this region of Southern Italy: Seneca also detected the true character of Somma (B.C. 1 to A.D. 64), and pointed out that its crater had thrown out more than its own mass of earthy matter, "being, in fact, a channel for the fire, but not its food."

By a careful study of volcanic mountains, we are enabled readily to perceive that they possess a marked similarity, their characteristic form being a cone, truncated at the summit by a funnel-shaped cavity or crater. The cone is found to be built up of ashes, scoriæ, and other loose materials ejected from the crater, and deposited in layers, which are thickest near the rim, and consequently attain a steeper angle as the cone increases in height. These loose materials are often bound together by outflows of liquid mud, or lava, and the percolation of rain-water, acting on the light tuffs and loose volcanic sand, converts them into a heavy and compact rock.

These alternating layers of ashes, lava, scoriæ, and mud, afford an interesting illustration of *subaërial* stratification resembling marine and fresh-water deposits, and, like them, often rich in organic remains.‡

But no marine or fresh-water deposits, however formed, could have preserved for nearly two thousand years the rich treasures of Roman painting and ceramic art, in all their freshness and beauty, which the buried cities of the Campania have revealed to us.

Liquid lava streams seldom issue from the cone of eruption, more frequently they make their escape from lateral vents at low levels. When lava rises and overflows the crater, it usually breaks down a portion of the wall, and so makes its escape.

Fragments of melted lava ejected from the cone harden instantly on their surface, while the interior becomes vesicular from the expansion of the gases and minute particles of water disseminated through the mass. The same is the case with the surfaces of lava streams.

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* Scrope, 'On Volcanoes,' p. 189.

† The contest between Earth and Sky which the Greek fable of *Typhœus* brings before us, is locally associated with volcanic energy in the region round Naples, Ætna, and elsewhere.—Phillips, p. 2.

‡ An eruption which occurred in the island of Arran in the Carboniferous period, has covered and enclosed a forest of erect trees in volcanic matter. Professor Phillips (p. 129) mentions seeing carbonized trees in lava near the Hermitage, Vesuvius.

Ascending obliquely, from the direction of Bosco Tre Case and Pompeii (writes Professor Phillips, p. 191, March 1868), "we reach a broad hot region, in which are the principal fumaroli; from these quite lately—last night—lava was flowing freely, now barely moving under a solid crust of pipy or cellular rock, deep sunk below the rest of the surface, or merely glowing in deep cavities, and yielding reluctantly to the pressure of a pole, which instantly takes fire. Beneath our feet, however, for considerable spaces, the ground is really fluid, only crusted over by the partially coherent and very partially cooled scoriaceous blocks. Removing these, where practicable, by the help of a pole, we see the sullen red lava below. The quickness of the consolidation of the surface of lava is remarkable; we stand on the solid crust, over what remains of yesterday's current, in a deep canal, which not long since ran full of melted rock; on this very hot surface it is requisite to keep in motion, if one has any regard for English shoes, but there is no other inconvenience.

"The air is hot, somewhat like that in the vicinity of iron-furnaces—which seems, whether it be so or not, a little deficient in oxygen, but no smell of sulphur, in any combination, and no fumes of hydrochloric acid."

The products issuing from the crater of Vesuvius are extremely various, as also are the conditions under which they are ejected. They may be roughly grouped under three heads, namely: 1st, Gaseous; 2nd, Liquid; 3rd, Solid. Under the first we may include carbonic acid, sulphuretted hydrogen, free hydrogen, hydrochloric acid, and nitrogen; under the second, liquid lava and streams of boiling water often charged with fine mud; the third includes ashes, pumice, lapillo, puzzolana, and volcanic bombs.

The gases referred to have been noticed in the exhalations from the fumarole of the lava of Vesuvius, and escaping from the numerous crevices in the sides of the vent after the termination of an eruption.

Lava-rocks, although differing more or less in mineral character, are all found, upon analysis, to be composed of silicates of alumina, or magnesia, with some protoxide of iron, potash or soda, and lime.

The texture of the great bulk of them is stony and granular, often highly crystalline; the component crystals of felspar, augite, or hornblende, mica, olivine, and perhaps quartz, being, though interlaced and interpenetrating, occasionally as distinct and large as in granite.*

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* Scrope, chap. vii., pp. 110 and 114.

Mr. Lobley furnishes us in his Appendix[*] with a list of the minerals found about Vesuvius and Somma on the authority of Professor Scacchi. Of these thirty-three occur in Somma, four in Vesuvius, four others are common to the lavas of both, and two were obtained from the fumaroles.

This great disparity in the relative numbers of mineral species met with in Somma and Vesuvius has a most important bearing on their origin in volcanic rocks, and confirms the opinion generally held by mineralogists, that a very large proportion of them owe their origin to a slow process of disintegration and re-combination of the constituents of volcanic tuffs, and lavas, in which rain-water acts a most important part as carrier.

The above opinion chiefly refers to those compound minerals which form the great bulk of Professor Scacchi's list, and does not in the least invalidate the observations of Bischoff, Darwin, Forbes, Monticelli, and Covelli, as to the formation of crystals of olivine, quartz, albites, leucite, &c., previous to the emission of lava, or whilst flowing at an exceedingly high temperature.

The most glassy and semitranslucent varieties of lava are known by the name of "obsidian." It does not occur in this condition around Vesuvius, but is abundant in the Lipari Islands, Mount Ararat, &c.

Large tracts in Mexico (called *Malpais*) are covered with "obsidian," and of it (as from the chalk-flint in Western Europe) the worshippers of the sun manufactured their knives, &c., which were still in use at the time of the Spanish conquest.

So long ago as 1825, Mr. Scrope arrived at the conclusion that the mobility of the solid component particles of liquid lava was not due to the mass being in a state of molecular fusion, in which condition it never occurs—subaërially,—but to the presence of an interstitial fluid disseminated through the mass, and that this fluid was water in a highly comminuted condition. This conclusion he seems to have arrived at from observing that the incandescent lava at the moment of its exposure and in the act of consolidation always gave off abundance of steam.

This hydro-igneous theory of lava has since been remarkably confirmed by the microscopic investigations of Mr. Sorby.[†]

The hard materials ejected from the crater are only diverse conditions of lava. Thus, when by the violent ebullition in the crater a more liquid portion of lava is shot up into the air, it assumes a globular or pearshaped figure, and is known as a volcanic "bomb." Other fragments of lava projected at a slightly lower temperature possess ragged, tattered shapes, and are full of vesicles; the heavier are called "scoriæ," the lighter "pumice."

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[*] 'Volcanoes of Central France,' pp. 54 and 55.

[†] 'Quart. Journ. Geol. Soc.,' vol. xiv., pp. 453–500.

The smaller fragments shot up vertically into the air are reduced by mutual friction to a sort of gravel called "lapillo;" still further comminuted into sand "puzzolana," and when reduced to fine dust, *ceneri*, or "ashes."

The distance to which these finely-divided ashes have been carried is prodigious. During one of the early eruptions of Vesuvius, A.D. 472, its ashes were carried as far as Constantinople, where the singular event was afterwards commemorated annually on the eighth of the Ides of November.

Among the sublimated mineral products of Vesuvius and its neighbourhood we must not omit to mention Sulphur; it enters most largely into the composition of volcanic mineral products, and also occurs in a pure state deposited in joints and fissures, especially round the remarkable crater called the Solfatara, near Pozzuoli, one of the all-but-extinct volcanic vents of the "Campi Phlegræi," west of Naples.

Vast beds of this mineral (deposited from the vapours of sulphuretted hydrogen) occur both in Iceland and Sicily, and are of great commercial value.

We come then to the active agent in all volcanic outbursts—Water. "Water," says Mr. Scrope, "we know is converted into vapour only at temperatures increased in proportion to the increased pressure to which it may be subjected; and when altogether hindered from communication with the atmosphere, as in a Papin's digester, or other closed vessel, may be made red hot without expanding into vapour.[*] The moment, however, that an opening is made in the enclosing vessel, reducing the pressure to that of the atmosphere only, it flashes instantly into steam with explosive violence. The same effect of course must take place in an imperfect liquid or paste composed of water and any solid matter in mechanical suspension or mixture, such as flour, clay, sand, or any other granular substance."

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[*] The *Annales de Chimie*, II., xxi. and xxii., record the experiments of Cagniard de Latour on the expansion of liquids under pressure.

De Latour partially filled some strong glass tubes with water, with alcohol, with ether, &c., and furnished them with gauges, and hermetically sealed them. He then cautiously raised the temperature. The alcohol (sp. gr. 0·844), which occupied two-fifths the capacity of the tube, gradually expanded to double its volume, and then suddenly disappeared in vapour, at a temperature of 497° Fahr.: it then exerted a pressure of about 119 atmospheres.

Water was found to become gaseous in a space equal to about four times its original bulk, at a temperature of about 773° (that of melting zinc). So great was the solvent power of water on glass, at this high temperature, that the addition of a little carbonate of soda was necessary to diminish the action on the glass, which frequently gave way until this expedient was adopted. As the vapours cooled, a point was observed at which a sort of cloud filled the tube, and in a few moments after the liquid suddenly reappeared.

From these experiments it would appear that there is a point in the temperature of every liquid at which no amount of pressure is sufficient to retain it in the liquid form.

Having thus seen the potency of water under pressure as the motive agent, and having the assurance of all observers, that water is always present, we may conclude beyond doubt "that the rise of lava in a volcanic vent is occasioned by the expansion of volumes of high-pressure steam, generated in the interior of a mass of liquefied and heated mineral matter within or beneath the eruptive orifice."

During great eruptions much forked lightning has been observed, darting forth in frequent flashes from the rising column of smoke and ashes. Mr. Scrope thinks that the intense mutual friction in the air of the ejected solid matter is sufficient to generate it; Professor Phillips, on the other hand, suggests that its occurrence is due to the rapid evaporization taking place and the vast quantity of steam liberated producing electric tension in a high degree.*

Professor Phillips mentions the observations of Professor Pilla, of Pisa, as to the occurrence of *flames* during volcanic eruptions. He evidently thinks them deserving of full credit, although he admits that in the majority of cases the light emanates from the surface of incandescent lava. We doubt one part of Professor Pilla's observation, that "Hydrogen was perceived *by the* smell!"† Surely this should read "*Sulphuretted* Hydrogen."

The theories as to the source of volcanic heat are many and various, but the one which may be said to claim the largest share of support is that which attributes the phenomena of volcanoes and earthquakes to the reaction of the interior of our planet upon its uppermost strata.

A volcano therefore exists only where there is a permanent connection between the interior of the earth and the atmosphere.

That such interior possesses a very high degree of heat is shown, not only by the state of fusion in which lava issues from volcanic vents, but also because, in proportion to the depth, there is a gradual increment of temperature observable so far as the solid crust has yet been pierced by artificial means.

Mr. Hopkins nearly thirty years ago, and subsequently Archdeacon Pratt and Sir William Thomson, have condemned as untenable, and contrary to the known laws of precession and nutation, the notion of a globe with a moderately thick crust and a fluid interior.

In order to produce a complete accordance in the motion of the entire mass, it is necessary, according to these authorities, to assign a solid crust of at least 800 to 1000 English miles in thickness.

Can any one believe that lava is pressed up through channels of that length?

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* P. 144.

† P. 154.

M. Delaunay has, however, clearly shown that "there is a fundamental error—not in the mathematical formula, but in the condition assumed, namely, that the interior is filled with a free-flowing liquid rock."

"The interior fluid can only be of the nature of lava, and that, when examined at the surface, however fresh, is a very intractable mass, flowing indeed as does thick honey, pitch, or slag; incapable of moving at the very utmost above a few miles an hour even on a slope of 30°, and on ordinary slopes only one mile, half-a-mile, or even thirty or forty feet in an hour. The problem solved by Mr. Hopkins, looked at in this light, does really not settle anything as to the thickness of the crust of the earth."

"The globe is continually, though very slowly, losing heat; it grows cooler in a very small degree, and suffers contraction in the same small degree." . . . "From what we certainly know of the constitution of the crust of the globe, it is of unequal strength to resist change of form in different parts. The weakest part must yield, and if by local yielding the general pressure may be satisfied (which is equivalent to supposing the general pressure determined to a small area), the displacement of a small tract may be extremely great, and the rocks there be bent into arches or broken by faults. If we are right in our views of the history of the globe, very many epochs would arise, when, first in one region, then in another, lines or areas of relative weakness would be depressed into concave seas, and receive a long series of deposits; and at other times the same areas or parts of them might be re-elevated, producing end-pressures and violent local flexures or fractures."

With these extracts from Chapter XII. of Professor Phillips's book we must now conclude this brief sketch of Vesuvius, hoping some day to be able to look at the probable connection between lines of volcanoes and volcanic centres and old volcanic areas now extinct, in other parts of the world.

IV. THE ARTIFICIAL PRODUCTION OF ICE AND COLD.

By Dr. B. H. Paul.

The application of heat for cooking food has been considered one of the most obvious characteristics by which man is distinguished from the lower animals, and there is even still greater reason for regarding the application of this physical agency for various economic and industrial purposes, as being one of the circumstances most important in determining the difference between civilized man and savages, and most conducive in various ways to the spread of civilization.

In most of the industrial arts the application of heat is involved in some one or other of the operations to be performed. Through the medium of vaporized water it is the principal means of locomotion on land and by sea, as well as the chief source of motive-power; while in the extraction and working of metals and in most productive arts, involving chemical alteration of raw materials, it is essential for bringing about the various changes to be effected. But though chemical alteration is in many cases the object to be attained in manufacturing operations, and then the application of heat is the means by which that change is facilitated, there are some cases in which it is desirable to hinder or prevent the chemical changes to which certain materials are liable even within the ordinary range of atmospheric temperatures. Thus, for instance, all articles of food, and especially those of animal origin, when kept for any length of time at the ordinary temperature, undergo a chemical change which renders them unfit for use. They pass into a state of putrefaction or decay, and are gradually resolved, under the influence of atmospheric oxygen, into the simplest forms of combination their elements are capable of assuming. For this change a certain temperature is essential, and though it probably cannot be prevented altogether, it is very considerably hindered by a reduction of temperature. Thus, for instance, in Siberia, the carcasses of mammoths have been found in a very perfect state of preservation, notwithstanding the vast lapse of time they have been buried in the frozen soil. In like manner meat, and game, or fish may be preserved for a long time quite fresh by keeping it at or below the temperature of freezing water.

For this and other purposes which require a low temperature, and where it is desirable to abstract heat instead of applying it to any substance, ice has been largely employed, and the importation of ice into this country from higher latitudes has become a very large trade since the year 1840.

Ice acts as a cooling agent in virtue of the physical fact that, in common with all solid substances, it requires an expenditure of heat for its conversion into the liquid state. The heat thus applied does not produce any elevation of temperature, but as the ice melts it disappears, so far as the indications of the thermometer will show, and there remains a quantity of water of the same temperature as the ice itself. Thus when ice or, still better, snow is mixed with three-fourths its weight of boiling water, the water remaining after the ice has melted, has a temperature of 32° Fahr., the same as the ice itself; the quantity of heat in the boiling water, corresponding to the interval of temperature between 32° and 212° Fahr., having been rendered latent, or expended in effecting the liquefaction of the ice. It is in this way that ice cools water, air, or any other substance it is brought in contact with, which has a temperature higher than 32° Fahr. Hence it will be seen that refrigeration, or the production of cold, is simply a manipulation of heat. It is an operation in this respect perfectly analogous to the production of a high temperature, in so far as both processes consist in the transfer of heat from one substance to another, and are subject to the same general laws. They are however reverse processes. Thus in generating steam, heat produced by the combustion of fuel is communicated to water. In making ice, on the contrary, heat is abstracted from water, and in this process the water which is cooled corresponds to the fuel burnt in generating steam, or in converting any other substance into vapour. Just in the same way that the fuel in burning yields its heat to the substance vaporized, so does the water, in making ice, yield its heat to some other substance capable of receiving it.

This is the nature of the work to be done in making ice, and it is now necessary to consider the amount of that work requisite for producing a given quantity of ice.

Water at the temperature of 60° Fahr. contains an amount of heat greater than that contained in an equal weight of ice at 32° Fahr. to the extent of 170·65 heat units* for each pound, consequently to convert water at 60° Fahr. into ice, it is necessary to abstract that amount of heat from it. Thus to produce a ton of ice the quantity of heat to be abstracted from water at 60° Fahr. amounts to

$$\overset{\text{Heat units.}}{382{,}256} = \overset{\text{lbs.}}{2240} \times 170{\cdot}65.$$

This is a quantity of heat not more than about one-eightieth part of that capable of being generated by the combustion of a ton of ordinary coal.

The means by which this amount of heat may be abstracted from water consist in producing some physical change involving an expenditure of heat, and doing this in such a way that the heat required for, and applied to that purpose, is abstracted from the water to be cooled and frozen. The conversion of any substance into vapour is a change of this kind, which involves an expenditure of heat similar to that taking place in the melting of ice. The amounts of heat thus absorbed by various substances in vaporizing are as follows:—

	Latent heat per lb. Heat units.	Authority.
Water	966·1	Regnault.
Liquid ammonia	900·0	Favre and Silbermann.
Alcohol	364·3	Andrews.
Ether	162·8	

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* The unit of heat here referred to is the quantity of heat required to raise the temperature of a pound of water from 40° to 41° Fahr., or one degree of temperature.

The amount of heat thus disposed of and rendered latent in the formation of steam from water is considerably greater than that existing in the latent condition in liquid water, or, what amounts to the same thing, that expended in melting ice; but the vaporization of water cannot be applied as a means of refrigeration to any great extent, because under the ordinary atmospheric pressure it does not take place readily or with sufficient rapidity at temperatures much below the normal boiling point, or 212° Fahr., and even when the pressure is removed by means of an air-pump, the vaporization of water proceeds very slowly at low temperatures. There are, however, other substances which vaporize readily under these conditions: and, for this reason, they are specially suited for artificial refrigeration, although the amounts of heat expended and rendered latent in their vaporization are less than in the case of water. Ether, alcohol, and liquid ammonia are substances of this kind; and, according to the foregoing data, expressing the latent heat of their vapours, the quantities of each of these substances which would have to be vaporized, in order to produce a ton of ice from water at 60° Fahr., or to produce a refrigeration equivalent to the melting of a ton of ice, would be:—

	lbs.
Ether	2,348·009
Alcohol	1,049·272
Liquid ammonia	424·728

From this comparison it will be seen that the expenditure of heat accompanying the vaporization of liquid ammonia is much greater than it is in the case of alcohol or ether, and that in this respect it is the most powerful as a refrigerating agent. But the amount of heat rendered latent in the vaporization of any substance is not the only, or even the chief point which determines its efficiency as a refrigerating agent. The degree of facility with which a substance vaporizes at low temperatures is of still greater importance, as will be evident from the following table, which gives the tension of the vapours at different temperatures below the boiling-points of the liquids under normal atmospheric pressure:—

		Ammonia.	Ether.	Alcohol.	Water.
Normal Boiling-point.		28°	95°	172°	212° F.
	° Fah.	inches	inches.	inches.	inches.
Tension of vapour in inches of Mercury at	104	463·64	35·81	5·26	2·16
	68	254·61	17·06	1·75	·68
	50	181·58	11·28	·96	·36
	32	124·52	7·22	·50	·18
	− 4	55·03	2·66	·13	
	− 40	20·81			
	− 109	9·45			

Since the tension of a vapour at any temperature is the measure of the facility with which the liquid evaporates at that temperature, it will be seen from the data in this table that, in this respect, there is a very considerable difference between the liquids there named. Here, again, the characters of liquid ammonia are such as to give it a marked precedence over all the other liquids, as a refrigerating agent, by reason of its relative capability of vaporizing at very low temperatures. This substance is in fact gaseous under normal pressure, within the ordinary range of atmospheric temperature, the boiling of the liquid being many degrees below the zero of Fahrenheit's scale; and at ordinary temperatures it requires a pressure of from eight to ten atmospheres—117 to 150 lbs. per square inch—to maintain it in the liquid state.

Alcohol, although it has a greater capability than ether of absorbing heat in vaporizing, is still inferior to ether as a refrigerating agent, on account of its being much less readily vaporized at low temperatures; and even ether evaporates so slowly at temperatures much below its normal boiling-point, that it can be used for refrigerating only with the aid of an air-pump to maintain the requisite rate of vaporization.

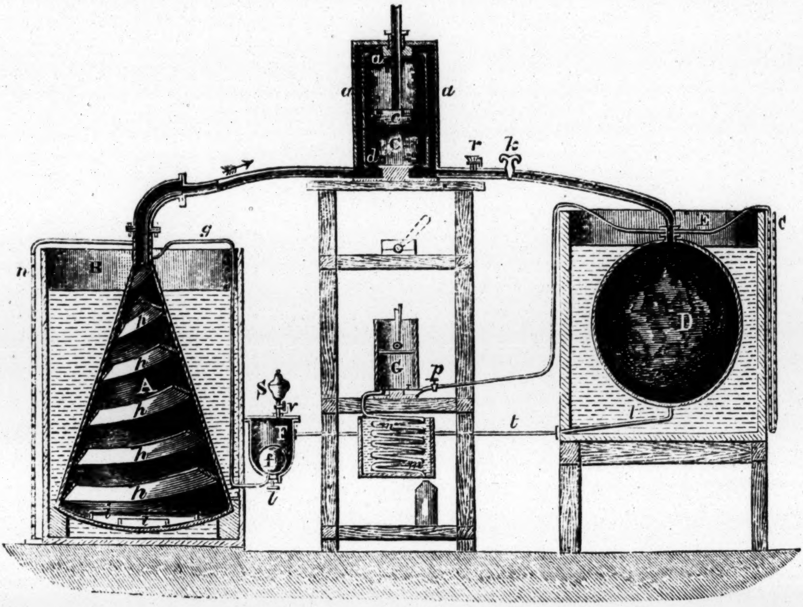
Liquid ammonia is therefore by far the most efficient material to use for this purpose, not only on account of its ready vaporization at low temperatures, but also because its power of absorbing heat in that change is but little inferior to that of water.

Another process, in which heat is expended and rendered latent, is the expansion of air. The amount of heat thus absorbed is at the rate of ·069, or about $\frac{1}{14}$th of a heat unit for each pound of air expanded to the extent of ·002035, or about $\frac{1}{490}$th of its volume at 32° Fahr. under normal pressure. If therefore air be compressed, say to one-tenth of its bulk, and, after being cooled to a low temperature, it be allowed to expand in such a way as to perform mechanical work, such as moving a piston, there is an expenditure of heat proportional to the resistance overcome and to the degree of expansion. Consequently the temperature of the gas is reduced during the act of expansion, and this effect may be taken advantage of for purposes of refrigeration. The chief disadvantage of this method consists in the great expenditure of power requisite for compressing the air, which involves a large consumption of fuel.

From what has been stated, it will be apparent that at present the choice of a refrigerating agent for producing ice or great degrees of cold, lies between ammonia, ether, and air, and that ammonia presents the greatest advantages for this purpose.

The expansion of compressed air appears to have been the means first adopted for making ice, by Dr. Gorrie of America; and in this country ether was the material employed in one of the earliest ice-making machines invented by Harrison, in 1856.* This was a very simple, but rather crude arrangement, represented by Fig. 1, and consisting essentially of an air-pump, c, connected with an evaporating vessel or refrigerator, A, on one side, and with a condenser, D, on the opposite side, so that, by the action of the pump, ether was continuously vaporized in the refrigerator, while at the same time, the vapour formed was withdrawn and forced into the condenser, where it was liquefied, and then returned to the refrigerator by a lateral pipe furnished with a valve.

Fig. 1.



The fundamental principles on which this apparatus was constructed were correct, but there appear to have been several serious errors made in their application, and the plan did not come into use in this country. The ether machine was afterwards improved by Messrs. Siebe in 1862,† and they have since applied themselves specially to the manufacture of these ice-machines. Most of those which have been made were for India and other hot climates, where it has been found more advantageous to make ice by artificial refrigeration than to import it from America, owing to the large amount of waste by melting during the voyage through warm latitudes.

In the year 1860 another apparatus was invented by M. Carré‡ of Paris, in which a very strong solution of ammonia was used as the refrigerating agent. The arrangements of this apparatus provided for the condensation of the ammonia vaporized in the refrigerator, in such a way that it was used over and over again, and the operation of the apparatus was continuous, as in the case of the ether machine. The woodcut, Fig. 2, represents this apparatus. A strong, vertical boiler, A, is charged with a concentrated solution of ammonia, to which heat is applied under a pressure of eight or nine atmospheres — 100 to 135 lbs. per square inch — and the mixture of gaseous ammonia and steam produced, passes off through an ascending coil of pipe, B, attached to the upper end of the boiler, into a tubular condenser, D, surrounded by cold water, where the distillate is cooled and liquefied under the pressure above stated. The condensed liquid collects in a receiver, *z*, and thence passes by the pipe *e e e* into the refrigerator F at a rate which is regulated by a special contrivance.

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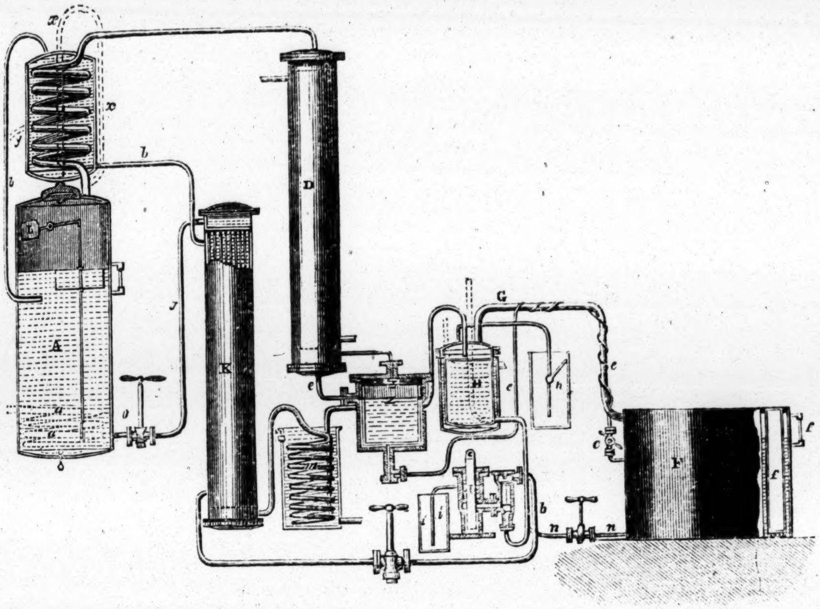
* Specification, No. 747. † Specification, No. 782. ‡ Specification, No. 2503.

Fig. 2.



The refrigerator F consists of a close vessel with tubes, *f*, closed at the bottom and open at the top, fitting tightly into the cover, so that the liquid ammonia surrounds them. Into these tubes cylindrical vessels are placed, containing the water to be frozen. The upper end of the refrigerator is connected by means of a pipe, G, with a vessel, H, within which the gaseous ammonia discharged from the refrigerator comes in contact with a continuous supply of cold water and is thereby absorbed, while the solution of ammonia produced is removed from the bottom of the vessel H by the pump I. In this way the gaseous ammonia is removed from the refrigerator and the pressure kept so low that the liquid ammonia is vaporized continuously, thereby abstracting heat from the contents of the tubes *f*.

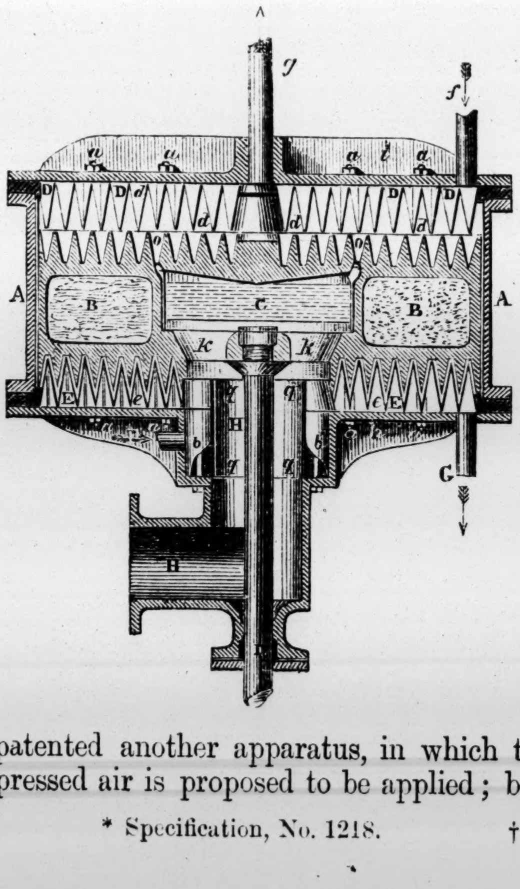
The solution of ammonia produced in the absorber H is forced by the pump I through the pipe *b b* into the outer casing of a tubular vessel, K, called the regenerator, through the tubes of which hot water exhausted of ammonia flows in the opposite direction from the boiler A. Here an interchange of temperature takes place, the solution of ammonia becoming heated while the exhausted liquor is cooled. The solution of ammonia, thus heated, then passes on into the closed vessel above the boiler and containing the coil B, where it is still further heated, while the gaseous ammonia and steam within the coil B are partially cooled and condensed, and it then flows by the pipe *b* into the boiler A, to serve for a repetition of the process.

The hot liquor exhausted of ammonia meanwhile flows from the boiler in a regulated current through the pipe J into the tubes of the regenerator K, thence through a cooling worm, *m*, surrounded by water, where its temperature is sufficiently reduced, and then passes into the absorber H, furnishing the supply of water for dissolving the ammonia as already described.

This machine has been largely used in the south of France for effecting the crystallization of salts by cooling, and several have been sent out to India for making ice.

In 1862 Mr. Kirk,* of the Bathgate Chemical Works, invented a machine in which the alternate compression and expansion of air was applied as the means of refrigeration, on the same principle as Stirling's air-engine for obtaining motive power. This machine, which is represented by Fig. 3, has been used in paraffin oil works for effecting the separation of solid paraffin from the oil; it has also been worked at Messrs. Flower's brewery at Stratford-on-Avon, and one has been sent to China for making ice. The arrangement of the machine is very good; but for making ice it is expensive, on account of the relatively large expenditure of power required. Messrs. Mort and Nicolle,† of Sydney, in Australia, have quite recently patented another apparatus, in which the expansion of cold compressed air is proposed to be applied; but the principle on which it

Fig. 3.



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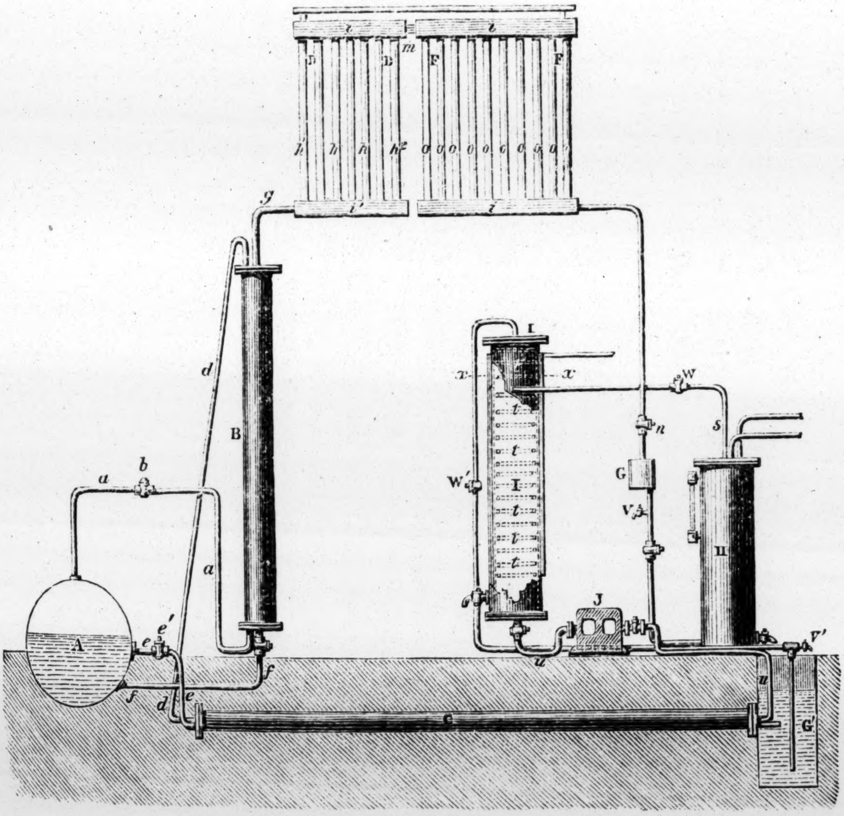
* Specification, No. 1218.

† Specification, No. 3278.

is based appears to be erroneous, and it is not likely to be effective for refrigeration, besides which their apparatus is far too complicated in its arrangements. Several other patents have been taken out for ice-making machines, but those already mentioned are the principal ones which have been tried.

An improved form of the ammonia apparatus, which comprises some novel features of very great importance in regard to the use of that material for refrigeration, was patented by Mr. Reece* in 1867. The arrangement of this apparatus is shown by Fig. 4.

Fig. 4.



The boiler A is charged with water or a very weak solution of ammonia, and the steam, discharged under a pressure of 100 lbs. per square inch, passes by the pipe *a a* to the bottom of a Coffey's analyzer, B, consisting of a tall columnar vessel with a series of plates arranged one above the other inside. Into the top of this vessel a concentrated solution of ammonia is pumped continuously, and in descending from plate to plate it meets the ascending current of high-pressure steam, the effect of their contact being to convert the ammonia into gas, while the steam is condensed and flows back

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[*] Specification, No. 1621.

again to the boiler A. The gaseous ammonia passes out of the analyzer by the pipe *g* into a tubular rectifier, D D, where the remaining steam is condensed and separated, while the ammonia passes on through a condenser, F F, where it is liquefied, and then flows through the pipe *e* to the refrigerator, H, the supply being regulated by a cock, *n*.

Meanwhile a regulated current of spent liquor passes from the boiler into a long tube, C, called the heater, fitted with an internal set of tubes, through which the concentrated solution of ammonia is forced by the pump J, into the top of the analyzer. By this means the solution of ammonia is heated, and at the same time the hot liquor from the boiler is sufficiently cooled to be supplied to the absorber I, into which it is forced by the pressure of the boiler, through the pipe *x x*, fitted with a cock, *w*, to regulate the supply. In the absorber I this water becomes saturated with gaseous ammonia discharged from the refrigerator H, and the resulting strong solution of ammonia is then pumped out into the analyzer.

The important feature of this arrangement consists in the application of the analyzing column B, and the rectifier D D, by which it is intended that the dehydration of the ammonia should be carried so far that the condensed liquid passing into the refrigerator may be practically free from water, while in Carré's apparatus the liquid supplied to the refrigerator contains 25 per cent. of water, and only 75 per cent. of actual ammonia.

The effect of this difference upon the working of the apparatus would be very great. Thus, for instance, the distillate passing from the boiler of Carré's apparatus, is separated into 95 per cent. of a liquor containing 25 parts of ammonia—which after being cooled is used for supplying to the absorber—and 5 per cent. of a distillate consisting of $\frac{3}{4}$ ammonia and $\frac{1}{4}$ water; which passes through the condenser without any further separation of the water. Therefore only $\frac{3}{4}$ of the liquid supplied to the refrigerator is ammonia; and since water, at the temperature of from — 22° to — 40° Fahr., which is produced in the refrigerator, is capable of dissolving and retaining in solution its own weight of gaseous ammonia, only two-thirds of the ammonia in the liquid supplied to the refrigerator will be available for refrigeration, the remaining third being retained by the water in that liquid, so that there will be a residuum of solution of ammonia, which must be run off from time to time from the refrigerator. Therefore since the effective refrigeration in an apparatus capable of making 5 cwt. of ice an hour from water at 60° Fahr., must be equivalent to the vaporization of 106 lbs. of ammonia within that time, it would be requisite to produce in the condenser a distillate at the rate of 212 lbs. per hour, for of this quantity 53 lbs. will be water, and that water will retain 53 lbs. of ammonia in solution, leaving only 106 lbs. available for refrigeration. Then, since the cooled exhaust-liquor, as introduced into the absorber, already contains 25 per cent. of ammonia, it will dissolve only $\frac{1}{20}$ of its weight more of ammonia; and consequently to maintain the required rate of vaporization it will be necessary to supply at the rate of 200 gallons exhaust-liquor per hour to the absorber,* and to pump nearly one ton of ammonia solution per hour into the boiler, against a pressure of ten atmospheres, which will require an expenditure of power to the extent of $\frac{1}{2}$-horse power per hour.

In the apparatus devised by Mr. Reece, on the contrary, it is proposed that the ammonia solution should be separated by the operation of the analyzer into 75 per cent. of liquor, containing five parts of ammonia, which is to return to the boilers, and into 25 per cent. of gaseous ammonia, which after being completely dehydrated in the rectifier, is to be delivered to the refrigerator almost entirely free from water. In this case, therefore, $\frac{5}{6}$ths of the ammonia distilled would be available for refrigeration, while in Carré's apparatus not more than $\frac{1}{24}$th of it is available. Then, since the exhaust-liquor in Reece's apparatus would contain only 5 per cent. of ammonia, instead of 25 per cent., as in Carré's apparatus, it would be capable of dissolving a further 20 per cent. Consequently for the same amount of work only $\frac{1}{5}$th as much would be required as in Carré's apparatus, and there would be only $\frac{1}{5}$th as much solution of ammonia to be pumped back into the analyzer.

These are advantages of a very striking and important nature, and, if realized practically, they would offer for the first time an opportunity of utilizing to the fullest extent the great capabilities of ammonia as a refrigerating agent, in such a way as to surpass all others in efficiency.

Little has hitherto been done in the application of artificial refrigeration to the making of ice in this country; but in hot climates, remote from natural sources of ice, it has been found to work very advantageously. Apart, however, from the actual production of ice, which from our proximity to Norway can be cheaply obtained thence in great abundance, there are many other purposes for which artificial refrigeration can be of great service. In preparing salt meat, for instance, a certain degree of cold is required to enable the meat to take the salt, and in this case the use of an apparatus capable of producing cold at pleasure would do away with the expense attending the transport and storing of large quantities of ice. Again, the influence of cold in preserving meat, fish, and other provisions, is sufficiently well established to justify the belief that artificial refrigeration might be applied with great advantage, not only in the transport of such materials from the country to the metropolitan markets, so as to ensure their arrival in better condition, but also as a means of compensating that uncertain and variable relation between supply and demand which sometimes renders articles of food excessively dear, and at others reduces their value to almost nothing. Large quantities of provisions are constantly being destroyed as unfit for food, on account of damage during transport, or from being kept too long, and this might in all probability be prevented if suitable means were applied to keep them cool, while being brought to market, and to store surplus supplies at a sufficiently low temperature for their preservation. Enormous quantities of fish are at times destroyed or carted on the land for manure, because, in the absence of any means of preserving an unusually large supply, it is not worth the cost of transport to market. In like manner the importation of what may be called the waste meat of the Australian colonies, South America, and of other countries, appears to depend mainly on a practical solution of the problem, whether a sufficiently low temperature for preserving the meat fresh can be maintained during the passage to England, at such a cost as would afford a profit on the trade.

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* See Report by Regnault, Balard, and Pouillet, 'Comptes Rendus,' 1862.

Another of the purposes to which artificial refrigeration may be applied with advantage, is the brewing of beer, especially as the necessity for cooling power is of uncertain occurrence, and varies very much according to the season, so that there is too great a risk in keeping a store of ice for the purpose, to admit of its being so much practised as might be desirable. It is, indeed, remarkable that so little has been done hitherto by brewers in applying artificial refrigeration, for with the exception of Messrs. Flower, of Stratford-on-Avon, who were the first to put up a machine for this purpose, and of Messrs. Trueman, Hanbury and Buxton, who have lately put up one of Siebe's ether machines at their brewery, there is, perhaps, no other brewery where artificial refrigeration is practised.

The practical benefit of such a means of producing cold at will, without incurring the expense arising from the waste of ice kept in store, has been well illustrated by the results obtained by Mr. King, the engineer to Messrs. Trueman's brewery, during the autumn of last year. The apparatus worked there is capable of producing five tons of ice within the twenty-four hours, with a consumption of coal at the rate of ten tons per week, or about 7*s.* per ton of ice produced; and the additional cost corresponding to expenses for labour, waste of material, and interest on first outlay, would probably fall far short of the average price of ice during warm seasons, when it is most in demand, and sometimes rises as high as 2*l.* per ton. But this is not the whole of the advantage capable of being realized in such a case by applying artificial refrigeration. In many cases it is by no means necessary for

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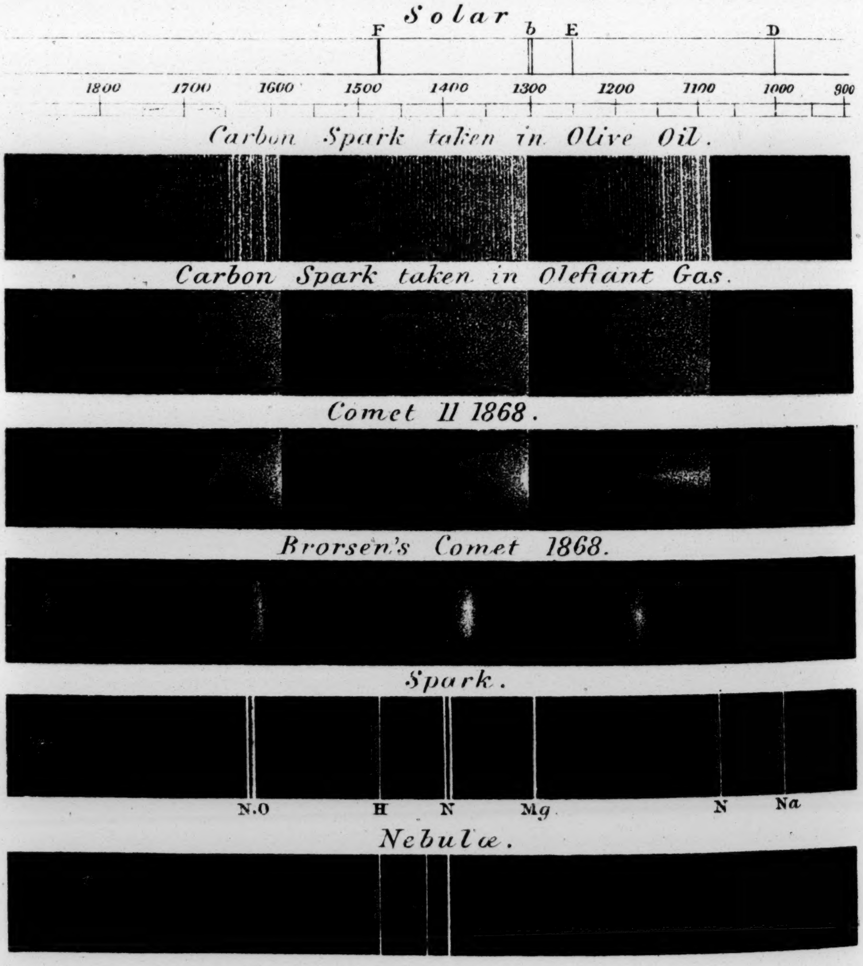
FIG. 1.

FIG. 2.



Solar

Carbon Spark taken in Olive Oil.

Carbon Spark taken in Olefiant Gas.

Comet II 1868.

Brorsen's Comet 1868.

Spark.

Nebulæ.

FIG. 3.

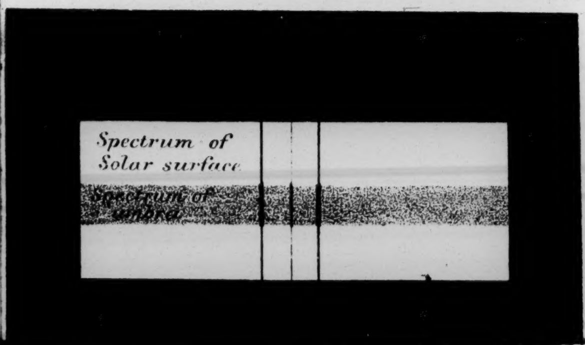
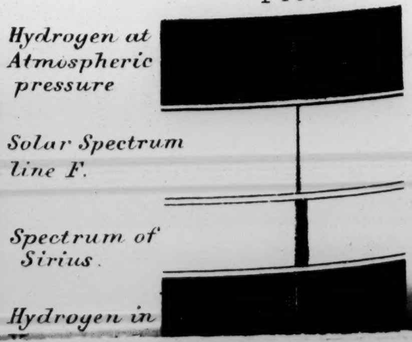


FIG. 4.



the object in view to produce ice, and, in fact, there may be a very great advantage gained by not doing so. Thus, for instance, Mr. King has, by an ingenious contrivance, arranged the working of his apparatus in such a manner that the refrigeration is applied directly to the material to be cooled, without making ice or using any refrigerating medium; and by this means he has succeeded, with the apparatus just referred to as capable of producing five tons of ice in twenty-four hours, in obtaining, during the same time and with the same consumption of fuel, an effect equivalent to the production of no less than *fourteen tons of ice*. This reduces the cost of the work done very considerably below the estimate already given, and the fact serves well to show what great benefit may be derived from the judicious application of refrigerating apparatus.

Among other purposes to which it has been proposed to apply artificial refrigeration, is the cooling of the air in dwellings, and in passenger ships passing through tropical regions;* and there are, no doubt, many other cases in which it might be usefully employed.

V. ON SOME RECENT SPECTROSCOPIC RESEARCHES.

By William Huggins, F.R.S., Hon. Sec. R.A.S.

It is the intention of the writer to give in this article an account of some of the more recent additions to our knowledge of the heavenly bodies which have followed from the application to them of that elegant and most searching method of analysis for which science is laid under lasting obligation to Kirchhoff.

The circumstance that in astronomy so large an amount of new and important knowledge has been gained, will not appear surprising when we consider how peculiarly spectrum analysis, which enables the observer to be independent of his distance from the source of light, and also of the length of time that the light has been on its way to him, is adapted for an examination of the light of the heavenly bodies, which are, for the most part, independent sources of light of a high temperature. Indeed the light of the sun, of the stars, of the nebulæ, and of comets, was written over with unread hieroglyphic characters, which, when the key was furnished by the German physicist, revealed to us information, such as it had appeared to man almost vain to hope ever to obtain.

Spectrum analysis, which consists in the skilled interpretation of the minute peculiarities by which spectra are distinguished, and the mode of its application to terrestrial objects and to the heavenly bodies, are now too generally known to need description here. It may be well, however, to state the principal forms under which all spectra may be classed, and the interpretation which, in the present state of our knowledge, we are justified in giving to these different spectra, when the light has been emitted by bodies rendered luminous by a high degree of heat. It is necessary to make this distinction, as it is not purposed to describe the spectra of fluorescent and phosphorescent substances.*

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* Mr. Shand, 'Society of Arts Journal,' xvii., 97.

The spectra of all highly heated bodies may be referred to three typical forms.

First Form.—When the continuity of the coloured band into which the light is dispersed by the prism remains unbroken either by bright or by dark lines. Now, as a general rule, such a spectrum may be interpreted as telling us that the body which emitted the light is in the solid or liquid state. Further than this, a continuous spectrum gives to us no information of the nature of the source of the light, for all solid and liquid bodies are characterized by a continuous spectrum, whatever their chemical nature may be.

Such is the interpretation which, as a general rule, and unless there should exist circumstances rendering a solid or liquid condition of the source of light highly improbable, ought to be given to a continuous spectrum. In certain cases gases may give a spectrum which is continuous. Dr. Balfour Stewart has pointed out that as gases and vapours possess a power of general or indiscriminate absorption, in addition to the elective absorption peculiar to each gas, it would follow that a gas when luminous would also emit light of all refrangibilities, producing a continuous spectrum, in addition to the spectrum of bright lines which is peculiar to the gas, and further, that the intensity of this continuous spectrum would be in proportion to the opacity of the gas.

Besides this consideration, the researches of Plücker and Frankland have shown that, under certain conditions of temperature and density, the bright lines of some gases expand, and so a spectrum may be produced which would not be distinguishable from that of the light of a solid or liquid body.

Second Form.—Spectra belonging to this class consist of bright lines. These lines tell us that the source of the light is luminous gas. Further, since, so far as observation extends, each gas and vapour is distinguished by a set of lines peculiar to itself, it becomes possible to discover if any of the substances known to us are present in the source of light. This method of analysis is not invalidated by the circumstance that the appearance of the lines may be greatly modified, or even altogether changed, under different conditions of temperature and density, as is well known in the case of nitrogen, the vapour of sulphur, and some other substances, for throughout all these changes each gas behaves in a way peculiar to itself.

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* For an account of the spectra of fluorescent and phosphorescent bodies, the reader is referred to 'La Lumière,' by E. Becquerel, vol. i. Paris, 1867.

As far as our knowledge goes, there appears to be but one exception to the statement that a spectrum of bright lines indicates luminous gas. Bunsen found that when solid erbia is heated to incandescence, the continuous spectrum contains bright bands.

Third Form.—This type embraces all spectra in which the continuity of the colours of the spectrum are interrupted by dark lines or bands. These gaps in the spectrum, which indicate that light of certain refrangibilities is wanting, do not teach us anything of the source of light itself, but show the existence, without the source of light, of vapours at a lower temperature, which, by a selective power of absorption peculiar to them, have quenched the light of certain periods of vibration only, and have not been able to make up for the light they have taken, by light of their own. As the kinds of light absorbed by each vapour correspond precisely with the set of bright lines which that vapour emits when in a luminous state, a comparison of the bright lines of substances that are known with the dark lines seen in a spectrum will show whether the vapours through which the light has passed are those of any of the bodies with which we are acquainted. The bright spectrum, in which the dark lines occur, must be questioned for information of the source of the light itself, according to the principles stated under the first form of spectra.

The foregoing statements form the canons of interpretation by which we are to be guided in our explanation of the spectra of the heavenly bodies.

The most important recent information obtained respecting the *fixed stars* results from the application of spectrum analysis in a new direction.

Under certain conditions, which will be stated, the spectrum of a luminous body is adapted to tell us whether that body is moving towards or from the earth.

It may be well, however, to point out in how remarkable a manner this new application of prismatic analysis supplies a want which astronomers had come to regard as one that could not be met by any method of observation within our reach. The stars, though apparently so immovable that they can serve as the figures on the dial-plate of the heavens to which all sensibly moving objects may be referred—the *fixed* stars, as it is still convenient to call them, are not absolutely motionless, like fiery studs riveted in the canopy of heaven. These brilliant points are found to shift their places to a minute extent relatively to each other. Small displacements are found which must be interpreted to represent a proper motion peculiar to each. Now, by ordinary methods of observation, that part only of a star's motion which is transverse to the line of sight can be detected, for the motion a star might have in the visual direction, either directly towards the earth or from it, would not cause any apparent change of position of the star, and would therefore remain undetected.

The method of photometry was clearly too coarse and too uncertain. Too coarse, for the eye, even when aided by suitable instruments, could not hope to distinguish the minute increase or decrease of brightness which would correspond to any velocity we could with probability assign to the stars, even if the observations were repeated at intervals of a thousand years. Too uncertain, for if the variations in the transparency of our atmosphere could be certainly eliminated, the large number of stars, of which the light is known to be variable, would forbid us to regard any alterations of brightness that might be observed, as trustworthy indications of the approach or recession of the star.

Now this radial motion of a star, which eluded our methods of observation, does record itself most fortunately in small alterations, which can be distinguished in the spectrum of its light. If the star be approaching the earth, a line, either light or dark, in its spectrum will be found to have moved from its proper place towards the blue end of the spectrum; if the star be receding from the earth, the line will have moved in the opposite direction, towards the red. The amount of shift of position produced by a star's motion will express exactly the proportion which its motion bears to the velocity of light. As the rate of propagation of light is known, the velocity of the star may be found.

The refrangibility, or the colour of a ray of light, or what is the same thing, the place in the spectrum which the light would take after it had passed through a prism, is determined by the number of pulsations or waves which meet the eye, or fall upon the prism, in a second of time. The special character which distinguishes red light from violet light consists in that the waves of red light are nearly as long again as those of extreme violet light. Now the velocity of propagation through the ether is precisely the same for all the colours of the spectrum. Red, yellow, green, blue light, emitted by a distant star, would reach the earth at the same instant, and it is for this reason that a new star, at the first moment that its light falls upon a human eye, appears of its true colour. Light travels with a velocity of about 185,000 miles in a second of time, a series of waves therefore extending through 185,000 miles enters the eyes each second. Now as it is upon the length of the waves, or upon the number contained in the series that enters the eye in a second, that a judgment is formed of the colour of the light, or the place of the light in the spectrum after passing through a prism is determined, it follows that any circumstances which would alter the length of the waves *relatively to the observer*, or in other words cause a large number of waves to enter the eye in a second of time, would cause a change in the colour or refrangibility of the light so far as the observer was concerned. An alteration in the velocity of the propagation of light would effect a change of wave-length, not, of course, intrinsically, but as measured by the eye which it entered, or the prism through which it passed. Less than twice the actual velocity of light would cause red light to be changed into violet, and all the other colours, the yellow, green, and blue, to be raised into force of that quality which exists in the long invisible spectrum beyond the violet.

Now it is obvious that the velocity of light is virtually altered to an observer moving in the direction in which the light is travelling. If the observer advances to meet the light, the velocity with which it enters his eye is increased, a longer series of waves falls upon the retina in a second of time, each wave appears shorter, and he therefore ascribes to the light a different colour, a higher refrangibility, than he would do if he were not advancing to meet the light. There is no change in the light itself, the alteration consists in a new relation of the observer to it.

To a swimmer striking out from the shore, each wave appears shorter, and he passes a greater number in a given interval in proportion to the speed of his progress through the water. If the distance between the men in a single file of soldiers be taken to represent the length of the waves of light, the distance will be diminished to a man meeting the soldiers, for he will pass a greater number of them in a given time than if he had been standing still.

Further, since the change of refrangibility depends alone upon the continually shortened distance between the observer and the source of the light, it is obviously of no moment whether the motion of approach belongs to the observer or to the source of the light. It requires no consideration to see that an opposite change in the refrangibility of the light will be produced by a motion of recession between the observer and the source of the light.

The idea that an effect upon the refrangibility of light would be produced by a motion of the observer or of the source of the light towards or from each other, is due to Doppler, who stated at the same time (in 1841) that an analogous change should take place in sound. In 1845 Doppler's theory was put to the test by Ballot, who published a series of acoustic experiments which confirm the correctness of the theory in the case of sound.

The comparatively slow velocity of sound through the air makes it an easy matter to give to the sounding body or to the listener a relative motion sufficiently great to produce a very sensible alteration in the pitch of the sound. In the case of light, however, which travels with a velocity of about 185,000 miles per second, it would be necessary to give to the luminous body and the observer a relative motion of 20 to 30 miles per second, even for such a minute change as could be just detected by a powerful spectroscope.*

The change in sound can be observed under many circumstances. The pitch of a railway-whistle when a train in rapid motion has passed the station of the listener is no longer the same as it was when the train was approaching. The sound of the whistle reflected from a wall is different from the sound which comes directly to the observer's ear. If two tuning-forks sounding in unison be held in the hands, and if at the same moment one hand be thrust suddenly forward and the other hand be drawn quickly backward, immediately to a listener standing in front of the experimentalist the unison will be interrupted by beats which tell of a difference of pitch produced on his ear by the opposite motions of the forks. Doppler in 1841 proposed by a similar consideration to account for the remarkable difference of colour observed in some double stars. But here he went wrong, for he overlooked the important circumstance, that if a star could be conceived to be moving with a velocity sufficient to alter its colour sensibly to the eye, still no change of colour would be perceived, for the reason that beyond the visible spectrum, at both extremities, there exists a store of invisible waves which would be at the same time exalted or degraded into visibility, to take the place of the waves which had been raised or lowered in refrangibility by the star's motion. No change of colour, therefore, could take place until the whole of these invisible waves of force had been used up; which would not be the case until the relative motion of the source of light and the observer was several times greater than that of light.

These considerations bring into prominence the conditions that must be fulfilled before the alteration of the refrangibility of light by the relative radial motion of the source of light and the observer can be employed to detect the motions in the line of sight of the heavenly bodies. It is essential, first, that we can ascertain the original colour or refrangibility of some part of the light at the moment when it left the star; and, secondly, that we can recognize this particular part of the light again in the spectrum of the star's light.

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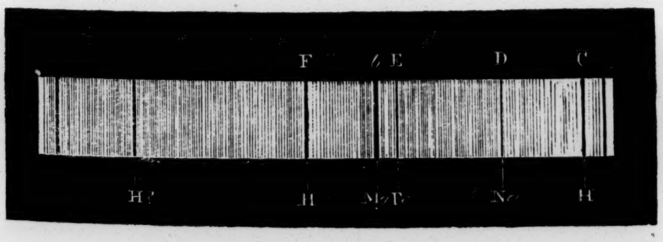
* The writer thought it might be possible to obtain an experimental illustration of the principle discussed in this article by observing an induction spark taken between electrodes of sodium placed at a little distance apart. It seemed possible that by the force of the spark the sodium, in a state of vapour, might be carried from one electrode towards the other with a velocity sufficient to alter the refrangibility of the lines of sodium when the spark was viewed in the direction in which it was proceeding. Several experiments, with a large induction coil, were made with the necessary care, but it was found that the vapour of the sodium remained very close about the electrodes, and no change of position of the lines in the spectrum could be detected.

Spectrum analysis enables us to obtain the information and to make the recognition which are necessary. When, by means of a group of dark or bright lines, we learn the presence of a terrestrial substance in the star, we possess the means of knowing with the greatest exactness the original refrangibility of those lines; and further, these dark or bright lines are objects which can be easily recognized, and can be compared directly with the lines produced by the same substance on the earth. By this method an observer can detect any minute shift from their original position which the lines may have suffered from the motions of the star and the earth.

For such an investigation it was necessary to choose a brilliant star, in the spectrum of which there were strong and very distinct lines, and which, by their coincidence as a group with the bright line of some terrestrial substance, showed that they were produced by the vapour of that substance in the star. Of all the stars which the writer had compared with terrestrial elements, when working with his distinguished friend, Dr. W. Allen Miller, Treas. R.S., Sirius appeared to fulfil most nearly these conditions.

The spectrum of Sirius (see woodcut) contains four very strong lines; two of these were found to be coincident, as seen in a spectroscope of two prisms, with bright lines of hydrogen; a third line is probably also to be regarded as a line of hydrogen. In addition to these strong lines, the spectrum is furrowed from end to end by numerous fine lines. Among these were found lines indicating the presence of sodium, magnesium, and iron. Nearly all stars of which the light is white or nearly so give a similar spectrum.

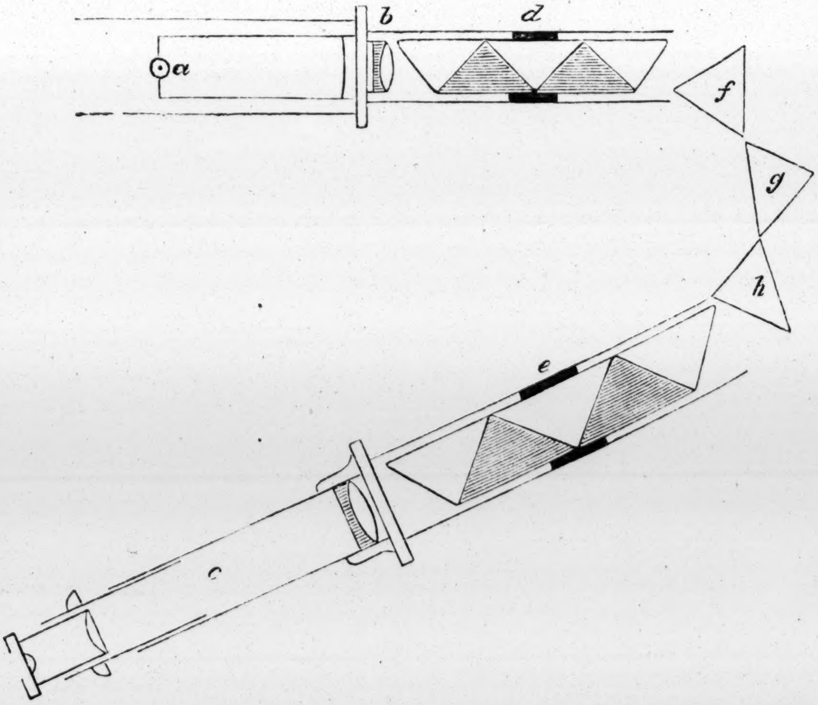
SPECTRUM OF SIRIUS.



Of all these lines, however, there is only one (the strong line due to hydrogen and coincident with Fraunhofer's F) which could be seen with the necessary distinctness when the powerful battery of prisms required for this delicate investigation was employed.

It may be well here to give an answer to an objection which may suggest itself to some readers. If the line in the star is not absolutely coincident with the line of hydrogen, would not the simple interpretation that the substance in the star is not hydrogen be preferable to the somewhat out-of-the-way hypothesis that the line has suffered a small displacement by the motion of the star? Certainly it would if we had one line only for comparison. Since, however, there are two strong lines in different parts of the spectrum, coincident, within the power of an ordinary spectroscope, with those of hydrogen, and a third line almost certainly coincident under similar circumstances, the probability is so great that hydrogen exists in the star, that we are, probably, justified in assuming that such is the case, and therefore in ascribing any very minute want of coincidence which a more powerful spectroscope may reveal, to a change which the light has undergone since it left the star.

The question then presented itself, how large a spreading out of the spectrum would be necessary in order to detect such a velocity of motion as might be expected from the observed proper motions of the few stars of which the parallax is known. The spectroscope which the writer had hitherto employed consisted of two prisms, and was competent to show a shift of position in a line equal to the distance which separates the lines D of sodium,



which would be equivalent to a velocity of about 190 miles per second. The velocities in a direction at right angles to the line of sight of the few stars, of which the distance is known, lie between twenty miles and sixty miles per second. An apparatus, therefore, equal to about seven prisms was needed to detect the amount of motion which was to be expected.

The circumstance that the writer possessed two fine compound prisms by Hofmann, of Paris, and some other considerations, led to the construction of an apparatus of the form represented in the woodcut on the opposite page. *a* is an adjustable slit, *b* an achromatic collimating lens, of 4·5 inches focal length; *c* represents the small telescope with which the spectrum is viewed. The train of prisms consists of two compound prisms, giving direct vision, *d* and *e*, and three simple prisms, *f*, *g*, *h*. The compound prism marked *e* is permanently connected with the telescope *c*, with which it moves. The compound prism *d* is so fixed that it can be removed at pleasure when the dispersive power of the instrument is reduced from about six and a half prisms of 60° to about four and a half prisms of 60°. It was with this instrument that the observations were made; but an apparatus in many respects superior has since been constructed for the writer.

A difficulty of some importance, and which had been expected, had now to be overcome. It was necessary to contrive a method by which the light from a substance to be compared with a star could be made to pass through the prisms in such a manner that the spectrum of comparison should be with certainty in absolute coincidence with the spectrum of the star. When the light to be compared is reflected into the instrument in the usual manner, by means of a small prism placed before the slit, a very small alteration of the position of the source of the light will cause the two spectra to shift upon each other to an amount much larger than the small differences of position which were to be sought for. In the former researches of the writer this source of possible error was constantly kept in view, and guarded against by a frequent comparison of the lines of sodium reflected into the instrument with those from a flame containing sodium placed before the object-glass. When the lines of sodium, as seen in both spectra, were truly coincident, the apparatus was considered to be in perfect adjustment. This method, however, was not found to be trustworthy for the more delicate investigation now in hand, since there existed the risk of a slight accidental displacement of the spark, or of the mirror by which it was reflected into the instrument, which would produce an error much more serious with the larger dispersive power now in use.

After the trial of some other methods, an arrangement was adopted which was found to be perfectly trustworthy. Two pieces of thin glass, silvered by floating them in a silvering solution, were fixed at an angle of 45° in front of the slit, a small space of about $\frac{1}{10}$ inch being left between them for the passage of the pencils of light from the object-glass. The invariability of position of the terrestial light relatively to the mirror was ensured by making it pass through a small hole in a plate of ebonite. This plan possessed two other important advantages. The two identical spectra of comparison were seen, one above the spectrum of the star, the other below it; and further, as the rays from the terrestrial light were divergent, they encroached a little upon the pencils from the object-glass at the slit, and caused the lines in the two spectra of comparison to overlap for a little distance the spectrum of the star. This state of things greatly assisted the eye in forming a judgment as to the absolute coincidence or not of a line in a star with that of a substance compared with it.

The comparisons, even when effected in this way, were not trusted to alone, but were checked by independent observations made when the light of comparison was placed before the object-glass of the telescope.

To return to the observations of Sirius. The only line in the star that could be successfully observed is the strong line at the position of Fraunhofer's F, which is due to hydrogen. Now this line of hydrogen is subject to great modifications under different conditions of density. Hydrogen at the atmospheric pressure gives a broad band of diffused light; it was, therefore, necessary to employ the hydrogen at a small tension. The light of rarefied hydrogen is resolved by the spectroscope into three bright lines. It is with the line at the blue extremity of the green that the comparisons were made.

In Fig. 4 of the Plate these lines are represented.

As the result of numerous observations on many nights, it was found that the narrow line of rarefied hydrogen did not coincide precisely with the dark line of Sirius, but appeared to be a little more refrangible.

After the excessive care that had been taken to eliminate every conceivable source of error, it is believed that the want of coincidence of the line in the star with that of hydrogen, may be accepted as a shift produced by the star's motion. The amount of the displacement represents a velocity of separation between the star and the earth of about 41 miles per second.

The writer then obtained evidence from experiment that the want of coincidence of the narrow bright line of rarefied hydrogen with the centre of the band in Sirius was not due to an unsymmetrical expansion of the line as the tension of the gas is increased. For this purpose a modified form of Sprengel's aspirator was constructed, and also a condensing apparatus, with which the spectra of hydrogen and some other gases were examined under different pressures. It is obvious that the hydrogen in Sirius is at a pressure considerably less than that of our atmosphere at the surface of the earth, but is more dense than the hydrogen in the solar atmosphere by which F is produced. This conclusion is in accordance with the presumably enormous mass of Sirius, as suggested by its great intrinsic splendour, which, according to some calculations, is 393 times that of our sun. Some more recent comparisons of its light by Alvan Clark, however, would give a somewhat smaller proportion.

The platform from which the astronomer observes is itself in rapid motion. The earth is moving through space, in its orbit round the sun, at about 19 miles per second. The part of the earth's motion, which will be in the direction of any star, either towards it or from it, will be different for different seasons of the year, and according to the star's position relatively to the plane in which the earth moves.

At the time the observations on Sirius were made, the earth was moving from the star with rather more than half its orbital velocity; this would leave about 30 miles due to the star itself.

Another correction has to be applied. It appears probable that the whole solar system is in motion towards the constellation Hercules, with a velocity of about 4 or 5 miles per second. As Sirius is situated in a part of the heavens opposite to Hercules, its motion must be further reduced to about 26 miles per second, the remaining (about) 15 miles of separation between the earth and Sirius being due to the two causes just assigned.

The true motion of Sirius will consist of this radial motion from the earth, compounded with the transverse motion which is shown by a small displacement of the star relatively to the neighbouring stars, and is known as its "proper motion:" this apparent motion represents a velocity of the star from 24 to 40 miles per second, according to the value which is assigned to the parallax of the star, that is, according to the distance at which we suppose it to be from the earth.

There are in the proper motion of Sirius certain *periodic* inequalities which led to the prediction, that there existed a body very near to Sirius, a prophecy which received a remarkable fulfilment by the discovery of a companion star to Sirius by Alvan Clark.

We now pass to some observations on that strange and mysterious order of heavenly bodies, the *Nebulæ*. The writer's former observations showed that the prevalent opinion, that all these objects were swarms of bright stars too remote to be separately distinguishable, could no longer be maintained. A large part of these objects give a remarkable spectrum (Fig. 2, Plate), which appears to be peculiar to the nebulæ. It consists essentially of three bright lines, though in some objects a continuous spectrum and a fourth line are also present. The writer showed that within the limits of the apparatus he then employed, the brightest of the lines was coincident with the brightest of the lines of nitrogen, and the third line with one of the lines of hydrogen. These objects were thus shown to be masses of luminous gas, of which the principal constituents were hydrogen and nitrogen.

Now it appeared possible that the application to these objects of the more powerful spectroscope, and more exact methods already described, by which the apparent coincidence of the nebular lines with those of nitrogen and hydrogen would be subjected to the test of a spreading out of the spectrum, three or four times as great as that previously employed, might furnish new information on two important points.

If the coincidence of the lines was found to be no longer maintained, then if it should be seen that both lines were, to about the same amount, a little more or a little less refrangible than the corresponding terrestrial lines, there would be reason to conclude that the want of coincidence was due to a motion of the nebula towards or from the earth. If a want of coincidence were observed in one line only, or in both lines, but in different directions, then there might be reason to infer that one or both lines were not really due to the substances nitrogen and hydrogen.

A careful re-examination of the nebula in Orion on several nights showed that the coincidence of one line with nitrogen and one line with hydrogen was perfectly maintained, a result which appears to show that the lines are really emitted by hydrogen and nitrogen; and further, that this nebula is not receding from us with a velocity so great as 12 miles per second, for such a velocity added to the earth's motion at the time would have produced a sensible shift of the lines. If, however, the nebula were moving in the opposite direction, it might have had a velocity of approach as great as 20 miles per second, for half of this amount would have been annulled by the earth's motion from the nebula.

The method of placing the spark before the object-glass brought into notice a fact of sufficient interest to be recorded. The great loss of brightness which followed from the distance at which the induction spark passing in nitrogen was observed, showed itself alike in the case of hydrogen and nitrogen by the total extinction of all the lines of the spectrum, with the exception of the one line in each spectrum which is found in the nebulæ. The obvious inquiry suggests itself whether the other lines of hydrogen and nitrogen were also originally present in the light of the nebulæ, and have been quenched on their way to us. As the nebulæ are objects of sensible size, we cannot attribute the extinction of the lines to the effect of distance alone. If one had reason to believe that the fainter lines of nitrogen and hydrogen have been extinguished on their way to us, we should have experimental evidence of the absorptive power on light, which, from theoretical grounds, was ascribed to cosmical space by Chéseaux and the elder Struve.

A fourth line has been detected in spectrum of the nebula of Orion, by Lieut. Herschel, in India, which appears to agree in position with a fourth line seen by the writer in the nebula 18 H. IV., and which is probably coincident with a line of hydrogen. The fourth line in the nebula of Orion has been also seen by Lord Rosse and by Professor Winlock, of the Harvard Observatory. These observers also suspect the existence of some other extremely faint lines.

The writer expects after a short time to continue his researches on the motions of the stars, and on the spectra of the nebulæ, with more powerful instruments than those he has hitherto employed.

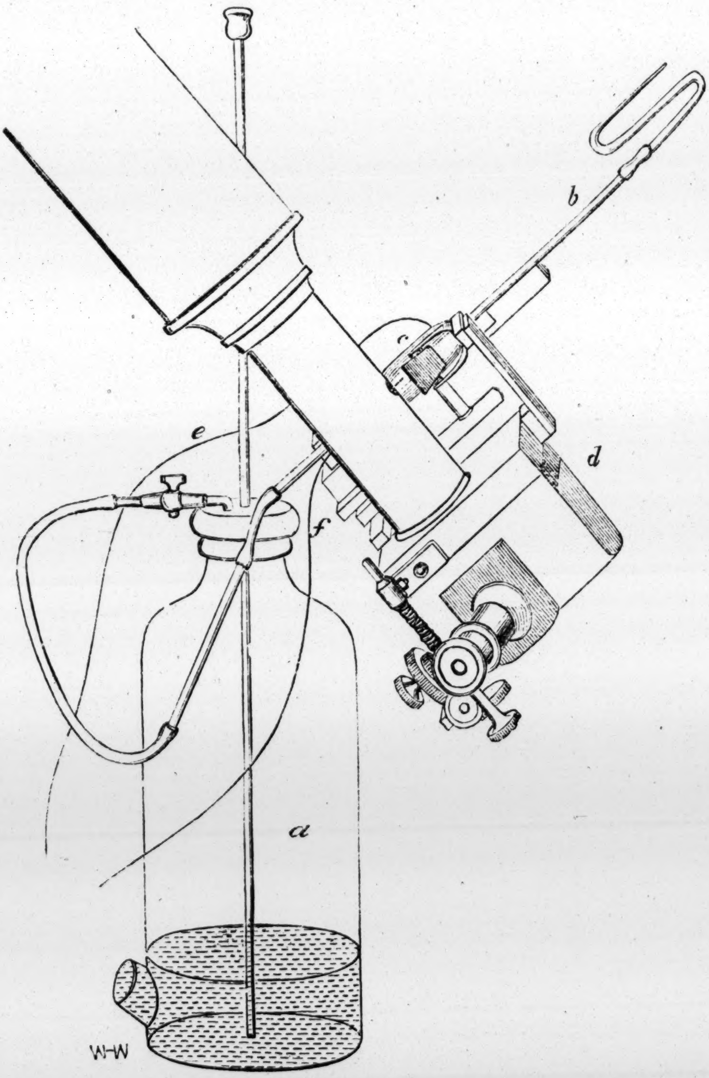
In the years 1866 and 1867 the writer observed the spectra of two small *comets*. The spectra of both these objects were compound, showing that part of the light was reflected and part probably emitted by the cometary matter. Last year two comets of superior brightness appeared, which permitted a more complete analysis of their light to be made.

The first of these was the return of the well-known comet of Brorsen, which was examined from May 2 to May 13. The second comet, a still brighter one, was discovered independently by Winnecke and by one of the assistants at the observatory of Marseilles. This comet was observed in June.

The spectra of these comets, which consist mainly of three bands of light, are represented in Fig. 2 of the Plate. These sets of bands, though they occur in similar parts of the spectrum, are far from being identical. It may be that from the faintness of Brorsen's comet the bands could not be traced so far; but even if it were so, this circumstance would not explain the considerable difference of position which exists between the bright well-marked beginning of the middle band. The positions of the bands in the spectrum are shown by the solar spectrum which is placed at the head of the diagram.

The morning after the observations of comet II., the writer was surprised to find that its spectrum appeared to agree exactly with one of a series of the spectra of carbon, as obtained from the decomposition of various carbon compounds which the writer had prepared a few years before. Two of these spectra are given in Fig. 2. It will be seen that though the light emitted by the carbon in both cases consists of the same refrangibilities, in the upper spectrum of the diagram the bands in the spectrum are resolved into narrow bright lines, while in the second spectrum, under similar conditions of the slit and of temperature, the bands remain undivided. These spectra are given not as exclusively peculiar to the particular combinations of carbon from which they were obtained, but as types of the spectra of a wide range of carbon compounds. The upper spectrum of bright lines was obtained by passing a powerful induction-spark between the points of platinum wires, sealed in glass tubes, through olive oil. A similar spectrum is given by the spark in cyanogen. The other spectrum of unbroken shaded light was obtained by the spark in olefiant gas.

It is with this modification of the spectrum of carbon that the spectrum of the comet appeared to agree precisely, not only in the position of the bands, but also in the special characters of the light of each band. The circumstance that in the comet's spectrum the bands become shorter as well as fainter towards the more



refrangible limit of each band was due to the arrangement of light in the comet itself. The appearance of the comet in the telescope is represented in Fig. 1; the slit was placed across the head of the comet. The greater brightness of the central spot permitted the middle part of each band, which was due to the light of this part of the comet, to be traced to a greater distance than the marginal parts which were produced by the fainter portions of the comet.

The same evening the writer put this apparent identity of the comet's spectrum with that of carbon to the test of a direct comparison of the two spectra. For this purpose a jar of olefiant gas was prepared, and the comparison was made in the manner shown in the woodcut.

The glass gas-holder *a*, containing olefiant gas, was connected by a flexible tube with a glass tube, *b*, into which platinum wires were soldered. This tube was so fixed that the spark between the wires was suitably reflected by the small mirror *c* into the spectroscope attached to the telescope, so that the spectrum of carbon appeared directly below the spectrum of the comet.

Very careful comparisons on that evening and similar direct comparisons on a subsequent night showed that in every particular the spectrum of the comet was similar to that of the spectrum of carbon as obtained by the decomposition of olefiant gas. The lines of hydrogen which are prominent in the spectrum of the gas were not present in the comet's spectrum.

Considering that the apparent identity of the spectra rests upon the positions of three bands and also upon the special characters of the distribution of the light in them, the conclusion may, perhaps, be considered well founded, that the source of a part of the cometary light is really due to carbon.

The difficulty of accepting what appears to be the obvious teaching of these observations arises from the very high temperature necessary to raise carbon to a state of vapour; for it appears to be alone when carbon is in the condition of luminous vapour that the characteristic spectrum of the bright bands appears. A degree of heat sufficient perhaps even for this purpose has been experienced by a very few comets. A temperature less excessive might be indeed sufficient, if we were free to suppose that comets consist of some compound of carbon which is decomposed by the sun's heat.

It is right to state that phosphorescent and fluorescent bodies give spectra containing bright bands. The former phenomenon appears to be restricted to solid and highly-reflective bodies, and the phosphorescence emitted by them is not seen so long as they are exposed to light. The phenomenon of fluorescence, when a nearly transparent liquid becomes an object of some brightness by absorbing the nearly invisible rays of the spectrum, and then dispersing them in a degraded and more luminous form, is less inconsistent with the small reflective power of cometary matter.

The violent commotions and internal changes of comets when near the sun seem, however, to connect the light they emit rather with a condition of great heat.

Some further considerations and speculations relating to cometary matter, and the phenomena which comets exhibit, will be found in a paper presented by the writer to the Royal Society.*

The invisibility on ordinary occasions of the bright prominences which appear round the sun at the time of a total solar eclipse is not due to the great splendour of the solar disc, for the sun could be easily eclipsed artificially by suitable diaphragms, but to the imperfect transparency of our atmosphere, which, on this account, near the sun is much brighter than the prominences which lie beyond it. When, however, the great natural diaphragm, the moon, cuts off the sun's rays before they reach the earth's atmosphere, the screen of illuminated air no longer exists, and the fainter phenomena beyond are seen.

In order to render the prominences visible without an eclipse, it is necessary to reduce by some means the light from the air in a much greater proportion than the light of the prominences. It is possible to do so, because while the solar light of the atmosphere consists of all colours of the spectrum, the light of the prominences is made up of three refrangibilities only. Any method, therefore, which would spread out the colours, or would produce absorption on certain parts of the spectrum, would diminish the brightness of the air relatively to that of the prominences, and might render them visible.

Though to Mr. Lockyer is due the first published statement of the possibility of rendering the prominences visible by the spectroscope, the same idea had also occurred, quite independently, to the writer, and to Mr. Stone, F.R.S. The writer tried the method on several occasions without success, in consequence of not knowing in what part of the spectrum the lines of the prominences would be found. When their places had been determined approximately by the observations in India of the solar eclipse, with the same instrument, he found the bright lines at the first moment of looking for them. Nearly three years ago it occurred to the writer that the form and appearance of the objects might be seen by means of coloured glasses and other absorptive media, by which the parts of the spectrum in which the bright lines occur could be isolated, and the light of all other refrangibilities extinguished by absorption.

By this method, combined with a modified form of spectroscope, he has found that it is possible to see the outlines of these objects.

In this connection it may be well to refer to an observation made on the spectrum of a solar spot. The sun's surface, when seen under favourable conditions, consists of aggregations of bright bodies, between which are minute spaces, more or less dark, which are known as the "pores." Such is the normal state of things, but temporary phenomena are of frequent occurrence, in which some of these minute pores are enormously increased in size, and become "spots." The inner portion of these spots is not uniformly dark, but contains usually a still darker spot. The writer in one instance found that the light of the inner part of a spot was about three times that of the light of the atmosphere near the sun's limb. When the light of the umbra is examined in the spectroscope the lines of Fraunhofer are found increased in width in a small degree, as is shown in the Plate, Fig. 3. Mr. Lockyer made independently a similar observation. In April, 1868, the writer found in the spectrum of a spot that the lines C and F were not widened. This observation is of some interest, now that we know that two of the three bright lines of the prominences are coincident with the dark lines C and F.

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* 'Phil. Trans.,' 1868, pp. 560–64.

The writer prefers not to build any speculations on these facts at present, since, in his opinion, the precise state of things which constitutes a sun-spot is not certainly known. The fragmentary character of the latter portion of the article has been owing to the writer's desire, not to omit some recent observations in this wonderful method of analysis, which promises to aid us in the solution of numerous cosmical problems hitherto deemed inscrutable, and greatly to extend our knowledge of the universe.

VI. THE FUTURE WATER-SUPPLY OF LONDON.

By C. W. Heaton, F.C.S., Professor of Chemistry in the Medical School of Charing Cross Hospital.

The long-expected Report of the Royal Commission on Water-supply will, it is to be hoped, be presented to Parliament in the course of the present session. Its publication will probably put us in possession of the most important document ever issued on this most important subject; for it is understood to contain many new and some rather startling results, in addition to the complete epitome of previously acquired knowledge, which was to be expected from the high reputation of its authors. In the meantime the public slumbers, as it generally does in England in the intervals of the periodical fits of energy in which so much of the real work of reform is done. To one whose study has brought him face to face with any of the great problems of sanitary reform, it is, indeed, a never-ceasing wonder that slumber, in the presence of such fearful questions, should at any time be possible; and he is apt to feel thankful to any monitor—even to the death-dealing cholera—that succeeds in awakening men to life and work. It is marvellous, certainly, that so enlightened, wealthy, and practical a nation as we boast ourselves to be, can live on in peace in the midst of such foul impurity as riots on every side of us; that we can even sleep in our beds and forget that tens of thousands of our fellow-countrymen are annually falling victims to this curse of man's stupidity and sloth, to this vampire of filth which haunts our towns and villages. And our wonder is increased when we remember the ineffably disgusting nature of the filth with which we are poisoned; that we are in very truth, in many cases, drinking and breathing human fœcal matter; and that the only consolation we are offered in these cases for the nasty fact, is the comforting assurance that it is "very much diluted!"

In considering the question of water-supply, it is important to notice at the outset, that it is inseparably associated with another question, which, for this and other reasons, is equally pressing, namely, the question of the disposal of sewage. The Reports of the Rugby Sewage Commission, and especially the elaborate and exhaustive Third Report, published in 1865, seem to leave no doubt upon this point; and it is satisfactory to find that the Pollution of Rivers Commission has adopted its suggestions, and has recommended the enforcement of sewage irrigation as the only way of preserving the purity of the streams. Many practical difficulties will no doubt have to be overcome, and some few doubts will still have to be cleared up, before this simple and rational method of utilizing sewage can be generally adopted; but enough has already been done to prove that success, in the great majority of cases at any rate, will be a matter of certainty. The Rivers Commissioners appear to have satisfied themselves upon one important point, and assert, in their Report on the River Thames (1866), "that no ground exists for serious apprehension of miasma from fields irrigated with sewage."[*]

If this process were generally and thoroughly applied, if the sewage were really passed through, and not merely over, the land, and the filtration, when necessary, repeated a second time, there would of course be a vast improvement in the quality of the river water. Land irrigation is by far the best mode of purifying sewage which is known, and is immeasurably superior to any method of precipitation. Precipitation, indeed, although it may, and often does, diminish the amount of organic matter present in solution in sewage, is rather a process of clarification than of absolute purification; whereas the action of grass-land is a chemical action, and, when properly applied, there can be no doubt that it affects a considerable alteration in the quality as well as quantity of the dissolved organic matter.[†] It will be seen that the urgent necessity for the adoption of this system raises a new question in regard to water-supply. It may be asked whether, supposing the water of a river can be kept free from the contamination of all sewage except that which has been filtered through meadow land, it will be safe to use it for drinking purposes? An absolute answer cannot as yet be given to this question; but considering the large amount of organic matter which often remains in solution in such filtered sewage,* and the extreme risk of the filtration being in some cases imperfectly effected, it is highly improbable that water so contaminated could ever be used with safety. For the sake of the rivers, and for the sake of the land, the sewage must be purified; but it should not be forgotten that, after all its purification, it will still be sewage—the diluted and somewhat modified excreta of human beings—and as such will be disgusting, and possibly dangerous, as an article of food. Whether purified or not, the sewage, it is evident, must in most instances be discharged into the nearest river; and we are therefore led by this view of the case to the general inference that rivers, below the highest points at which they receive sewage, are unfit sources of water-supply.

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[*] P. 12.

[†] Way, Evidence before Select Committee on Lea River Conservancy Bill, May, 1868.

But the subject of the sewage-contamination of water cannot be dismissed quite so easily as this. Very contrary opinions are held in regard to it; for although no one doubts that water largely contaminated with recent sewage is likely, or, rather, almost certain to lead to epidemic disease, many persons believe that, provided the admixture be small and that it has flowed for some miles down the stream, the well-known self-purifying power of the water, due to its dissolved oxygen, will have destroyed all organic bodies in it, and have rendered the sewage perfectly innocuous. This is the view held, very naturally, by the London water companies, and strenuously supported by Dr. Letheby, their consistent and zealous advocate. The question has been chiefly argued in relation to the cholera, and it will therefore be convenient to keep to that issue, although it must not be forgotten that sewage-polluted water is quite as deeply implicated as a cause of other forms of epidemic disease. Let any one who doubts this read the 'Report on Typhoid Fever at Tottenham,' by Dr. Seaton, and at Buglawton, by Dr. Buchanan. Both are printed in the Appendix to the Ninth Report of Mr. Simon, the medical officer of the Privy Council, 1867.

This last-named Report, together with the excellent 'Report on the Cholera Epidemic of 1866,' by Dr. Farr,† which forms the supplement to the Twenty-ninth Annual Report of the Registrar-General, afford ample materials for a consideration of this question, a consideration which is forced upon us by its close and intimate connection with our immediate subject. It is unnecessary to multiply proofs that water contaminated with choleraic discharges is a frequent cause of the disease. Some of the most striking were adduced by Dr. Frankland, in the admirable paper which he contributed to this Journal in July, 1867. To the cases there quoted may be added the frightful sporadic outbreak at Theydon Bois, in Essex, in the autumn of 1865, where nine persons out of a family of twelve, including servants and a visitor, died of the disease in a few days, and where it was distinctly proved that the first patient, and some of the others in turn, had from a defect in the sewage arrangements caused a contamination of the well-water.

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* 'Third Report of the Sewage Commission, 1865,' p 46.

† Published 1868.

The history of the epidemic in Newcastle in 1853, quoted by Dr. Farr, is not less instructive. But it must be understood that these numerous instances would be overstrained if we argued from them that choleraic water was the sole cause of cholera. Other causes, no doubt, are efficient in many cases for the propagation of the disease. Contact with cholera patients; the washing of their clothes; dust impregnated with choleraic discharges;* and the noxious emanations of sewer gases, have all been traced as causes in cases where water could not have been concerned. Dr. Macpherson† quotes the case of the Baltic fleet, in which distilled water only was used, and in which a violent epidemic took place; and in his lucid Report on Cholera in Southampton, in 1866,‡ Dr. Parkes exculpates the water-supply altogether, and succeeds in fixing the stigma upon the exhalations from a large volume of sewage which was being pumped through an open conduit at the time. This case is the more important, because the number of deaths reached a total of over 20 to 10,000 of the population, and because a similar cause is alleged by Mr. Orton as conducing to the epidemic in East London.

In all these dissimilar cases, however, there is one common circumstance to be noted, and to that the communication of the disease is almost invariably to be ascribed. The dejections of the sick, whether carried by air, water, or direct contact, have undoubtedly the power of infection; and the elaborate researches of the last few years have illustrated the cause of this power in a most remarkable manner. The zymotic theory of cholera—that theory which traces the origin of the disease to the presence and development in the intestinal canal of some peculiar form of organized matter—has for the last twenty years had many adherents, and the evidence of observation and experiment in support of it has increased materially of late, and has acquired a very high value. The subject is not one for a chemist to dwell upon, but it is impossible to avoid a slight reference to it here, as it lies at the root of the question of the safety of river water. Those who require more detailed and trustworthy information may find abundance in Dr. Farr's Cholera Report, and also in Appendix No. 11 to Mr. Simon's Ninth Annual Report; both of which have been already quoted. The final conclusion of the best observers on the subject seems to be, that the active agent in cholera is to be found in certain "choleragenic molecules" (they receive different names by different writers), or germs of very low forms of life. These molecules are exceedingly minute—not more than $\frac{1}{25000}$th of an inch in diameter—and seem to be indistinguishable in appearance, though so very different in power, from the molecules of other zymotic diseases.* They are discharged in myriads in the flux of a cholera patient; and hence it probably is that this flux is the main agent in the conveyance of the disease. Dr. Farr proposes to call them "cholrads," and the choleraic matter containing them "cholrine." There is great convenience in the use of these terms, and for the future I shall adopt them. By careful experiments with this cholera matter Hallier succeeded in cultivating it in various artificial soils, and producing definite forms of fungoid growth. Dr. Thiersch, in 1854, and more conclusively, Dr. Burdon Sanderson, in 1866, made experiments on the action upon mice of papers steeped in cholera flux. Both found that a disease closely resembling cholera could be produced in this way; and these and other similar experiments seem to leave no doubt that this is the normal mode in which the infection is conveyed. What it is chiefly important to notice here is, that the specific poison of cholera is in all probability not a definite compound, like arsenic or strychnine, but a series of extremely minute solid particles, each of which, if placed in suitable conditions, may by fissiparity develop into an infinite number. The number which may be communicated to a river by the discharges of a single cholera patient can, of course, only be guessed at. One thousand millions of the cholrads would not occupy a larger space than a pin's head; and Dr. Farr gives a curious calculation, founded, for illustration, on the assumption that their number in the cholera flux is equal to that of the globules in the same volume of blood. According to this calculation, a single patient would introduce into the river no fewer than 41,769,000,000,000 of the cholrads. Now, the volume of the Thames at high water, from Bow Creek to Teddington, may be taken approximately as 14,000,000,000 gallons, and each gallon might, therefore, become contaminated with 2983 cholrads! † The general properties of cholrine, as far as they have been ascertained, are well summed up by Dr. Farr. Its development is arrested by acids; and this, no doubt, accounts for the efficacy of sulphuric acid in premonitory diarrhœa, and affords a probable explanation of the apparently partial and occasional action of the poison. No doubt, certain favourable conditions of the body are necessary for the development of the germs, and these conditions may chance to be absent in any given number of cases. Dr. Frankland has found, as Chaveau found with vaccine granules, that cholrine cannot be separated from water by filtration—a fact which, from the exceeding minuteness of the cholrads, is not to be wondered at. Careful filtration, no doubt, removes very much of the noxious matter, the cholrads being probably entangled by the solid matters separated; but their complete separation would appear to be impossible. This most alarming fact is, however, to some extent, neutralized by the probability that a certain quantity of the poison is required to render its operation at all a matter of likelihood;* and by the further certainty that the germs cannot live for any great length of time in the water, unless recent fœcal matters are present; in which case, it is of course possible, that they may develop and reproduce themselves in the water, though no distinct evidence on this point has been obtained. Finally, a certain external temperature is necessary for the action of the poison; and when present in small quantity, it is absolutely impossible to detect it by chemical methods.

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* Dr. Mudge, 'Med. Times and Gaz.,' May 18, 1867.

† 'Med. Times and Gaz.,' July 13, 1867.

‡ 'Ninth Report to Privy Council,' p. 244.

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* Beale. To whose marvellously careful observations much of our knowledge on this subject is due.

† An error occurs in Dr. Farr's calculation, arising from the circumstance that Vierordt's estimate of the number of the blood-corpuscles is copied from the 6th edition of 'Carpenter's Physiology,' where it is incorrectly given as 5,069,000 per cubic *centimètre*, instead of per cubic millimètre. I have introduced the right figures in the text.

The whole history is unpleasant in the extreme; and the drinkers of sewage-contaminated water will be apt during warm weather to think more of the horrible possibility connected with their sparkling beverage, than even of any of the probabilities which its vendors may be able to allege in its defence. To take the case of the present water-supply of London. There can be no doubt that the sewage of thousands upon thousands of persons is thrown into it before it is collected by the companies. When cholera is prevalent, cholrine must be thrown in with this sewage, which at all times must contain the germs of some zymotic disease. Now it may be, and probably is in many cases, that the whole of the soluble organic matter is oxidized before it is consumed as drink; but who would like to trust to this probability? And even if the whole of the unorganized matter of the water were oxidized, there exists no security that the organized germs, the really mischievous part, would also be oxidized and rendered inert. Dr. Frankland points out,† that such germs would probably resist oxidation for a longer time than mere organic matter in solution. To quote his forcible illustration, an egg thrown whole into the Thames at Oxford would probably retain its vitality at Teddington; but the same egg, if it had been broken and its contents beaten up in water, might have suffered complete oxidation in the same time.

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* Farr, *op. cit.*, xv.

† Frankland and Armstrong 'On the Analysis of Potable Waters,' Journal of the Chemical Society, March, 1868.

Although, therefore, we may for the present be forced to remain contented with doing our utmost to secure the *minimum* of sewage-contamination in our water-supply, it is highly probable that in the future these makeshift precautions will not satisfy us. It behoves us of course to be extremely careful in deciding on radical changes in our water-supply; for although the case so far looks very black against sewage-contaminated water, the possibility must not be lost sight of, that it may ultimately break down altogether, and the London companies succeed in proving that no possible harm can arise under any circumstances from the use of their water.

The history of London water-supply and its connection with the cholera is a very important element in the inquiry to which we are thus impelled. Some points in it have been made the subjects of very fervent, if not acrimonious discussion, and to these points it is now necessary to allude as briefly as possible. The three last epidemics of cholera in London have found three different conditions of water-supply; and Dr. Farr has proved in the clearest manner that the progressive amelioration which has been effected in the quality of the water, has been accompanied by a corresponding diminution of the mortality of the disease. It is unnecessary to quote evidence on this point, because Dr. Frankland has given enough to convince any sane person, in his before-named article in this Journal. The fact is not indeed, as far as I am aware, doubted by any one. 'The Metropolis Water Act of 1852,' which prohibited the London companies, after the 31st August, 1865, from drawing their supply below the tidal points of the Thames and its tributaries, and compelled them to filter it, was undoubtedly the cause of the very slight virulence which marked the epidemic of 1866 in all the districts of London, with the important exception of those which were supplied from one reservoir belonging to the East London Water Company at Old Ford, Bow. We all know the terrible catastrophe that befel that fated region; we all read at the time, with lively sympathy and horror, the vivid narratives which week by week were compiled by Dr. Farr and the other investigators of the tragedy. The story need not here be told in detail. The acuteness of Dr. Farr soon suggested a probable cause for the localization of the outbreak; and Mr. Netten Radcliffe, who was specially commissioned by the Privy Council to inquire into the circumstance, and whose elaborate Report is printed as an Appendix in the Ninth Report of the Medical Officer, found himself compelled to adopt his hypothesis. It cannot now be doubted that the water of the ordinary reservoir at Old Ford was, on a particular occasion, shortly before the outbreak in East London, contaminated with some unfiltered and probably foul water from one of two open reservoirs on the other side of the river Lea. Shortly before the probable date of this contamination (for the exact date cannot be fixed), the first two deaths from cholera in this district had occurred in Priory Street, Bromley, about 600 yards lower down the river. The open reservoirs were close to the river, which in this place is tidal, and the banks which divided them from it were almost certainly porous. It is therefore alleged that some portion of the poisonous discharges of the two Priory Street victims, which were undoubtedly thrown by the sewer into the Lea, found its way into the open reservoirs, and being from one of these admitted into the covered reservoir, carried its deadly infection throughout the whole district. Such is the result arrived at by Mr. Radcliffe from a variety of considerations, the chief of which may be taken to be the necessity of *some* definite cause having been at work to produce so peculiar and well-defined an effect. He establishes with great force the general localization of the epidemic in the sub-districts supplied with the water, and discusses *seriatim* all the causes which could be conceived to have occasioned this localization. Altitude, soil, density of population, filth, sewerage, and locality, are all considered in turn, and are all dismissed, either as not having been unfavourable, or as not having presented any marked differences from the condition of other places. By the application of this method of exclusion, he is led to the adoption of the water-theory which I have stated, and which has received the adhesion of Mr. Simon, as well as of Dr. Farr, who, in fact, originated it. He writes with singular moderation and impartiality, and has saved his opponents much trouble by the care with which he has pointed out the weak points of the theory.

It was, of course, not to be expected that views so damaging to vested interests should pass unchallenged; and a keen controversy has, in fact, been waged in regard to them, although the bulk of the medical profession has, I believe, accepted the conclusions of the Government officials. The most able collection of arguments that I have seen on the other side of the question is from the pen of Mr. Orton, the medical officer of health for the Limehouse district,* who has suggested some points which, as even Mr. Radcliffe admits, present grave difficulties. He argues that East London was in a very much worse condition than the rest of London in respect both of filth and of sewerage; and the picture which he draws of the sanitary condition of the neighbourhood is very striking, and is described with unusual power. The account of the Limekiln Dock Sewer, with its filthy windings, its syphons, or

* 'Report to the Board of Works for the Limehouse District for the year ending Lady-day, 1867.'

semicircular channels, intended for carrying sewage under canals, but serving, in addition, to collect and store up the more solid filth; its ventilating shafts and gully-gratings, and its final discharge into Limekiln Dock, is highly suggestive; and in reading the description, it is difficult to avoid the conclusion that so noxious a set of conditions must have contributed in some measure, at any rate, to the virulence of the explosion.

The high and middle levels of the northern drainage system unite at Old Ford, and the united torrent is carried on to Barking Creek. The unfinished low-level sewer, "choking with filth, from whatever source it came, probably from Poplar, took its course in this direction, right through the centre of the Limehouse district, on either side reeking with pestilence, into Ratcliffe Highway." My own local knowledge is not sufficient to enable me to decide upon the extent to which these various abominations may account for the sharp boundaries of the area of explosion; but Mr. Radcliffe, while admitting their probable influence, does not regard them as sufficient to account for the special phenomena observed. He remarks that East London was not peculiar in respect of unfinished sewerage works, for that all places on the line of the low-level sewer must have been in the same condition, and that the middle and high level sewers flowed through many places besides East London. But, on the other hand, it must be remembered that the mere circumstance of these places being situated higher up the line of the sewer, would, as Mr. Orton remarks, render them less likely to suffer injury from the sewage, the sewage being less in quantity, and probably less foul. Be this as it may, it cannot be doubted that the influence of filth on the course of the epidemic is deserving of careful inquiry, and this is freely admitted by Mr. Radcliffe himself.

Another formidable objection to the water-theory of the explosion is founded by Mr. Orton on the fact that certain places, and notably Stamford Hill and North Woolwich, which were continuously supplied from the Old Ford reservoir, did not suffer from cholera. The circumstance is highly remarkable; and Mr. Radcliffe is only able to explain it by showing the possibility that the infected water was really not distributed to the places in question until the day after the contamination, when the poison may be supposed to have become too dilute to be operative. Dr. Farr, however,* while noticing the fact that water was distributed to North Woolwich on the constant system, a circumstance that, by ensuring the main being full at the time of the contamination, would probably prevent the district from receiving the first portions of the contaminated water, suggests that in these remote districts the cholrine might well be supposed to have become precipitated, in virtue of its greater density, before the water was delivered. Mr. Radcliffe * makes the important admission that he holds the immunity of these places to be fatal to the idea that the water of the Old Ford reservoir was, during the epidemic, constantly and directly impregnated with choleraic poison by infiltration from the river Lea. If this be true, the case against the East London Company must rest entirely on the use, on one occasion, of water from the open reservoir; and the whole explosion must then be traced to the two deaths in Priory Street. I own I think this admission goes too far; for, looking to the whole circumstances of the epidemic, coupled with the history of other epidemics, I am constrained to admit the strong probability that the water-supply was implicated; and yet, on the other hand, I am unable to refer the whole explosion to the limited cause assigned by Mr. Radcliffe. My reasons for this rejection of Mr. Radcliffe's theory may be stated briefly.

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* 'Cholera Report,' xxvii.

The two deaths in Priory Street took place on the 27th of June, 1866. It appears probable that the contamination of the Old Ford reservoir occurred early in July, and the distribution of unfiltered water must therefore have followed the deaths in a few days' time. In the week ending July 14th the outbreak may be said to have commenced in East London; but the real force of it was not manifested until the following week, when the deaths suddenly rose to a most alarming extent. The following figures, taken from Table 21 in the Appendix to Dr. Farr's 'Cholera Report,' will serve to illustrate the progress of the epidemic. They refer solely to the East districts of London and the district of West Ham.

Week ending	Deaths from Cholera.
July 7, 1866	3
„ 14, „	41
„ 21, „	438
„ 28, „	1002
Aug. 4, „	1046
„ 11, „	664
„ 18, „	341
„ 25, „	169

An examination of these figures naturally suggests the inquiry, How many of these deaths can be supposed to have been the effect of cholrine discharged into the sewer on June 27th? Now, the experiments of Thiersch and Dr. Saunderson, already quoted, prove that cholrine, at any rate when dried on paper, is almost inert, when fresh, attains its *maximum* of activity on the third day, and is again inert by the sixth.

Probabilities are, therefore, against the idea that the discharges of the two Priory Street patients, could have acted as poison, unless they were actually drunk within six days afterwards, that is, before July 4th. Moreover, the period of incubation of the poison in the body is believed to be short. Dr. Farr says on this subject, "There is reason to believe that the period of incubation is as brief as the term of attack in fatal cases of cholera; the cholrine often acts as suddenly as any of the poisons."* And again, in another place, "It may now be laid down as an established law, that water into which cholera dejections find their way produces cases of cholera all over the district in which it is distributed for a certain period of time; and that if the distribution is in any way cut short, the deaths from cholera begin to decline within about three days of the date at which the distribution is stopped."†

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* 'Report,' p. 325.

Mr. Radcliffe, indeed, instances the outbreak at Theydon Bois, in order to show that the period of incubation may be somewhat longer than is here suggested, for in that instance several persons were attacked on the sixth day after the disuse of the water. If, however, we assume the utmost in every respect, and allow six days for the period during which the cholrine retained its activity in the water, seven days for the period of incubation, and three for the duration of the attack,‡ we are still compelled to admit that the Priory Street cases could only have led to those deaths which took place within sixteen days after the 27th of June, that is, at the outside, before the 14th of July. The above-quoted table shows us that only forty-four deaths occurred in this period, and it is difficult to imagine how the special contamination of the Old Ford reservoir can be made accountable for more than this number. If the view of the case be correct, the cause, or rather perhaps the causes, of this terrible mortality which followed are still to seek. Very probably the bad sanitary condition of the district aggravated the epidemic, and the mere establishment of the disease in a place is almost sure to lead to its increase by personal contact, the influence of impregnated soil, sewer gases, &c. But none of these, or even all of these combined, appear to me to account for the singularly well-marked and all-but universal prevalence of the disease in the districts supplied with the Old Ford water; and, in spite of some difficulties and apparent contradictions which beset the question, I find myself constantly led back to the belief that the Old Ford water must have contained cholrine. We can never know the exact truth of the matter, and must be contented to accept probabilities as our guide; and it appears to me much more probable that the Old Ford water should, either by infiltration from the Lea, or in some other manner, have become impregnated with cholera poison, than that the remarkable localization of the epidemic should have been entirely fortuitous. Dr. Letheby* has indeed suggested that the area affected coincides pretty nearly with that supplied with gas by the Commercial Gas Company, and that the gas might as well be accused as the water. But this ingenious special pleading will not bear a moment's examination; for not only is the coincidence between gas and water supply less perfect than is pretended, but bad water is well known as a very frequent cause of cholera; and it is absurd to suppose for a moment that gas has anything to do with it.

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* 'Cholera Report,' xxxiii.

† Ibid., xxxix.

‡ About four-fifths of the deaths from cholera in England in 1866, excluding cases in which no return was made on the subject, took place within three days of the first attack, *vide* 'Cholera Report,' Table 12.

Most of the other evidence that is brought against the water theory of the epidemic of 1866, is founded on the immunity of individuals of certain houses or streets, and of some public building, where many persons were assembled during the epidemic, and which were supplied with water from Old Ford. The case of the Limehouse schools is perhaps the most striking instance of this kind. In this establishment nearly 400 pauper children lived in perfect health throughout the epidemic. Not a single case of cholera or even of epidemic diarrhœa occurred, although the children used the Old Ford water continuously. The sanitary arrangements are, indeed, described as excellent; every precaution that could be devised to prevent an outbreak of the disease was employed; and, instead of standing upon porous gravel, as the surrounding buildings do, the schools stand upon a thick bed of fine brick-earth, into which the soakage of sewage is impossible; but still the case is certainly curious, though it cannot be regarded as proving anything. The death-rate from cholera in Limehouse during the epidemic was 107·6 in 10,000; so that, if the average had been strictly preserved, four or five deaths would have occurred in the building. But uniformity cannot possibly be looked for in the distribution of an epidemic; and just as the mortality in some streets and houses was much above the average, so it must necessarily have been lower in others. No one thinks of supposing that water was the sole cause of the mortality; and it is not by any means wonderful that the well-fed and well-cared for inmates of a healthy building should have escaped the infection. The error lies with those who persist in assuming that the cholera poison is of the nature of arsenic or strychnine, and that it is therefore sure to produce the disease in every individual who takes it; the truth being, as we have before seen, that any given number of individuals may take cholrine into their stomachs without injury, and that they may even drink cholrine-contaminated water without getting any of the cholrine. A similar argument was brought forward by Dr. Letheby in respect to the London Hospital. In his evidence before the Select Committee of the House of Commons on East

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* 'Evidence before Select Committee of House of Commons on East London Water Bills,' p. 429.

London Water Bills,* he stated that in the London Hospital, which is exclusively supplied with water from Old Ford, there was not, during the whole of the epidemic, one case of cholera among the ordinary inmates or attendants of the hospital. This statement, which is said to have been repeated before the Royal Commission on Water-supply, would, if correct, have supplied us with a still more curious instance than that of the Limehouse schools; but, unfortunately, it appears that Dr. Letheby's knowledge of his own hospital was inaccurate, for in the official hospital returns Mr. Bathurst Dove gives a detailed account of *seven* cases of cholera which occurred among the hospital attendants, and *one* among the ordinary patients. Six of these cases terminated fatally, including the patient, a child; so that, out of the 130 attendants employed in the hospital, five died—a proportion of 385 in 10,000!

It is now necessary to consider the amount and nature of the evidence which science is able to offer on the quality of water intended for drinking purposes. With respect to the mineral constituents of a sample of water, chemical analysis, of course, enables us to speak with great certainty and accuracy; and geology can, in most cases, account satisfactorily for the results of the analysis. It seldom happens, however, that a water which is used for drinking purposes contains any ingredient which, either from its nature or exorbitant amount, is likely to be deleterious to health. When calcium or magnesium salts are present in large quantity, they render the water inconveniently hard, and are therefore objectionable, as leading to an enormous waste of soap; but this is a subject which has been so fully discussed by Dr. Frankland in this Journal that it may now be passed over. Some of the mineral constituents which are found in ordinary waters, though entirely harmless in themselves, are yet of great significance, as throwing light on the previous history of the water. Thus ammonia and nitrous and nitric acids must be determined with the utmost care in the examination of a water, because, with the exception of a small and never-exceeded quantity which is derived from rain, they arise in the great majority of cases from the alteration of animal exuviæ in the water. So, again, with common salt and other chlorides. Though sometimes present naturally in waters uncontaminated with organic matter, any large quantity of them may generally be regarded as a sign that sewage contamination is present. For an analogous reason the gases dissolved in water yield valuable indications; oxygen being usually deficient and carbonic acid in excess when organic matter has undergone recent oxidation in the water. All these constituents can be estimated with the most astonishing accuracy even when present in extremely minute quantity, and it is from a collation of these results that the previous history of the water is written. From the amount of nitrogen present, as ammonia and nitrates and nitrites, *minus* the quantity which may have been derived from aërial sources, Frankland calculates the "previous sewage-contamination" of the water on the assumption, founded on many analyses, that one part of nitrogen is contained in 10,000 parts of average London sewage. Of course, it must not be forgotten that this estimate includes previous *drainage* as well as previous sewage-contamination; for land drainage, especially in times of flood, carries to the rivers much of the soluble portions of the excreta of animals in a more or less complete state of decomposition; and it is obviously impossible to distinguish in a water the nitrogen which comes from sewage from the nitrogen which comes from drainage. But in spite of this drawback, the estimate of previous sewage-contamination in the London Companies' waters agrees so well with calculations founded on the number of persons whose sewage pollutes the streams, that it may, I believe, be accepted as a marvellously close approximation to the truth.

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* 'Minutes of Evidence,' p. 45.

It is very much to be wished that we were able, by equally direct and accurate processes, to determine the quantity and nature of the "organic matter" which exists in solution in all polluted waters, except those in which natural oxidation has proceeded to its furthest limit. But, unfortunately, the very nature of the subject precludes us, and will perhaps for ever preclude us, from knowing much about the nature of this organic matter. For what is organic matter? It includes, according to the views of modern chemistry, all except the very simplest of carbon-containing compounds. The phrase is indeed only exceeded in vagueness by the idea for which it stands, and has been long discarded from the realm of pure science, in company with the "extractives" and "earthy matters" which formerly marked unknown regions on the map of science. To find organic matter in water is nothing. Sugar is organic matter, so is strychnine, and so is a worm, or the contents of an egg. In the complex wanderings which water often pursues in its journey from the clouds back to the sea, it is obviously liable to become contaminated with "organic matter" from the most various sources. It may pass through peat; through living plants or dead vegetation; through a paper-mill, a dye-house, or a soap-boiler's, or through all three; it may receive the washings of a pig-sty, the drainage of a town, or the garbage from a butcher's shop; and its composition will differ in every one of these cases. Moreover, if we knew exactly what contaminations the water had received, and their chemical nature, we should still be unable to say in what condition they existed in the water as we found it. For nearly all kinds of organic matter commence a complex series of changes from the moment they enter the water—a series which is only completed by entire oxidation. These changes, no doubt, vary greatly with the nature of the organic matter, the amount of free oxygen which it meets with, the conditions of rest or agitation, the temperature, and so on. They belong to that most complex department of chemistry which deals with the processes of putrefaction, fermentation, and decay, and as such they are connected in some direct, but ill-understood manner, with the vital changes of low forms of organic life in the water. It is not wonderful that in such a chaos we should have to pick our way carefully, and should be compelled to decide rather by inference than direct proof, on the nature and significance of the organic contaminations in our river and well waters. The methods upon which reliance is placed vary from time to time as sounder views and wider knowledge are acquired, and they are still very imperfect, but enough has been done to justify great hopes in the future. It is unnecessary in this place to enter into the details of the recent improvements in analytical method, but some of their leading features must not pass unnoticed.

The old incineration process, in which organic matter is estimated by igniting the dried residue and noting the loss of weight, appears now to be pretty generally discredited. Its indications cannot, of course, furnish the least clue to the nature of the volatile matter, and do not even correctly record its amount; for even when all precautions are taken, some of the mineral substances, such as ammonia and nitrates, are sure to be volatilized, wholly or in part; and Frankland and Armstrong have, on the other hand, shown that urea, a very significant and important impurity, is not entirely volatilized during the process. To show the utter untrustworthiness of the method, it will be sufficient to mention that a water residue sometimes weighs more after ignition and treatment with carbonic acid than it did before. In such a case the analysis would, of course, indicate rather less than no organic matter!

The permanganate of potash process, suggested in the year 1850 by Forchhammer, has in the last few years been very largely employed, and has received many modifications of form. The permanganate, when applied in solution to the acidified water, loses a definite portion of its oxygen to the organic matter present; and the amount of oxygen so employed can be ascertained by the amount of the beautiful violet solution of the salt which is decolourized. Most chemists are content to record the amount of oxygen so indicated, or, at any rate, the amount of permanganate employed; but Dr. Letheby calculates the organic matter from the oxygen by multiplying its weight by eight. This would give a perfectly correct result, if all organic matter were equivalent to oxalic acid in its action on the permanganate. But this is so far from being the case, that it appears, from the careful experiments of Frankland and Armstrong, that of nine different kinds of organic matter experimented upon, oxalic acid was the only one which was perfectly oxidized even in six hours. All the others escaped oxidation to a greater or less extent; and such important compounds as urea, creatin, and cane sugar, were scarcely oxidized at all. Moreover, although one part of oxygen will oxidize eight parts of oxalic acid, it could only oxidize perfectly 0·47 part of urea, 0·45 of creatin, or 0·89 of sugar; so that even if the oxidation effected by the permanganate were perfect, the calculation would be wrong. The consideration of the irregularity in the action of the permanganate test has induced Dr. Frankland and some other eminent chemists to abandon its use altogether; and in the present state of our knowledge this is perhaps the safest course to pursue; but I am by no means convinced that it may not, even yet, be made a most valuable auxiliary test in water analysis when properly used. In an interesting and suggestive pamphlet 'On the Examination of Water for Organic Matter,' by Dr. Angus Smith,* to whom we owe the earliest and some of the most successful attempts to discriminate between different kinds of organic matter in water, will be found many important details on the mode of using the test, and interpreting its results. I regret that space precludes me from quoting some of his results. I have derived much instruction from the perusal of the paper, and can only hope that the author will follow up his experiments, which appear to have been unavoidably postponed.

A new and very ingenious method of water analysis was presented to the Chemical Society of London on June 20, 1867, by Messrs. Wanklyn, Chapman, and Smith, and is more fully described in a little work published by the two first-named chemists in 1868.† The chief process is conducted in the following manner:—The quantity of ammonia in the water to be examined is first determined in the usual way by means of the Nessler test. Another portion is then mixed with carbonate of soda, and a fraction of it, usually about one-third, is distilled off, measured, and the ammonia it contains estimated as before. To the residue in the retort is now added an alkaline solution of permanganate of potash, and the liquid again distilled until a very small bulk remains. A third determination of ammonia is made in this distillate, and from these results three different portions of nitrogen are determined in the original water. The first portion exists in the water, as ammonia; the second is believed by the authors to exist as urea; and the third as albuminoid substances. If these distinctions were exact; if the whole of the nitrogen of urea could be recovered as ammonia in the first distillation, and the whole of the nitrogen of the albuminoid compounds in the second, this method would be, as far as it went, perfect; but, unfortunately, this is not the case. Pure urea does not yield the whole of its nitrogen under the circumstances of the experiment, and neither does pure albumen, unless with extreme difficulty. The authors believe that the ammonia obtained bears a definite and constant relation to the amount of those compounds present, and think themselves justified in calculating the amounts of urea and albuminoid compounds from the figures they obtain; but such a method is obviously inferior to one which should give more positive results. The process is very easy of application, and, as an empirical method of judging of the goodness or badness of a water it is certainly valuable. It gives concordant results; and though it is somewhat difficult to give a distinct interpretation of those results, without venturing on hypothetical ground, it may, I think, safely be used, when the more exact method of Frankland and Armstrong cannot be applied, as a means of judging whether a given sample of water is, or is not, fit for drinking purposes. Water which yields very minute traces of the so-called ureal and albuminoid ammonia, and is free from nitrates, can never, I believe, be injurious.

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* London: Taylor and Francis, 1868.

† 'Water Analysis: A Practical Treatise on the Examination of Potable Water.' London: Trübner and Co.

The process of Frankland and Armstrong, alluded to above, is described in their previously quoted paper, and is unquestionably the most important contribution to the study of potable water which has ever appeared. In this wonderfully exact and ingenious method, the dried residue of the water, which has been previously deprived of carbonic, nitric, and nitrous acids, by boiling with sulphurous acid, is ignited with chromate of lead in a combustion-tube sealed at one end, and connected at the other with a Sprengel-pump, by which a perfect vacuum is effected at the commencement of the experiment. During the ignition of the residue, the organic carbon is converted into carbonic anhydride, and the nitrogen is evolved either free or as nitric oxide. When the combustion is complete, the pump is again worked, and the gases formed during the experiment swept down by the falling mercury, and collected in an ordinary mercurial trough. They are then removed to another piece of apparatus, and measured and analyzed by known methods. Such, divested of details, is an outline of this remarkable process. It will be seen that no attempt is made by it to ascertain the absolute amount of organic matter present; but it furnishes us with precise information in regard to two of the most important elements of that organic matter, namely, the carbon and nitrogen. From the nitrogen found in the experiment must be deducted that present in the original water in the form of ammonia. A separate experiment must be made for this purpose, and a second for the determination of the nitrogen present, as nitrates, and nitrites, which yield their nitrogen in the form of nitric oxide when agitated with mercury and sulphuric acid. As the nitrogen, present as nitrates, nitrites, and ammonia, are used as a measure of previous sewage-contamination, so the organic nitrogen may be made an index to the *present* sewage-contamination, on the same assumption as before, namely, that one part of nitrogen corresponds to 10,000 of sewage.

With regard to the presence of organized germs, such as cholrads in the water, their chemical composition would probably approximate to that of albumen; but their minute size, as it has hitherto rendered it impossible to detect them in water by the microscope, so it serves to place them beyond the reach of chemical methods. Even if we could distinctly prove the presence of albuminoid compounds in a sample of water, it would, on chemical evidence, be impossible to say whether or not it was organized. It might consist of white of egg, or it might consist of cholrads, for anything that an analysis could show. The only safeguard which can be adopted against the presence of noxious germs in our drinking-water is, as I have already said, the complete exclusion of all sewage from sources of the supply.

Although the microscope has hitherto failed to detect in water the germs of zymotic disease, it must not be supposed that its indications are of no value in the diagnosis. When Dr. Hassall was preparing his Report to the Committee, which, in 1854, was commissioned by the Medical Council of the General Board of Health to make scientific inquiries in relation to the cholera epidemic of that year, he observed and described a great many low forms of life in the waters consumed in London. Some of the animal forms are terrible-looking monsters, and the coloured drawings in which they are portrayed are by no means pleasant to contemplate.* But Dr. Hassall states explicitly that none of these tiny monsters can be identified in any way with the cholera, for all of them are found frequently when cholera is absent. In like manner he found vibrions in myriads in "every drop of every sample" of the rice-water discharges of cholera patients which he examined; but knowing the ease with which vibrions are developed under a variety of circumstances, he did not venture to connect them in a causal relation with the disease. But we must remember that animalculæ are formed of albuminoid compounds, and that if their germs develop in the water, it is a certain proof that the nourishment necessary for their subsistence is present. In pure water it is impossible for organic life to be developed; and the presence of such life may therefore be taken as a certain proof of nitrogenous and therefore probably of sewage contamination. In fact, I cannot help agreeing with Dr. Angus Smith, in the belief that the microscope is too much neglected in examinations of water.

The length to which this article has already extended has left me but little space for a consideration of the various projects for the amelioration of the water-supply of London which are now before the public. I regret this the less, because it would be premature to express a decided opinion on their respective merits until the appearance of the Report of the Royal Commission on Water-supply. It would indeed be folly to attempt the work of criticism in anticipation of the full particulars which that document will no doubt supply on each of the separate projects; but a slight sketch of their leading characteristics may, perhaps, be found useful. The schemes may be divided generally into those which propose to confine the source of supply to the Thames basin, and those which propose to take the supply from a distance. There is, indeed, one scheme—that of Mr. A. S. Ormsby*—which belongs to neither of these classes. He proposes to collect rain-water by means of vast roofs of glass and iron, so arranged that the water may immediately flow off into receiving, and hence into settling, filtering, storage, and distributing reservoirs. These might be constructed either in the immediate neighbourhood of London or on Salisbury Plain, where, by roofing in a space of 2012 acres, a supply might be obtained that would, the author estimates, supply one gallon of pure water per head per diem to the inhabitants of London. The ground below the roofs might be employed by market, fruit, and flower gardeners. The supply would, of course, be only supplementary to the ordinary supply; and we should, therefore, be provided with water of two qualities—one for drinking, and one for all other purposes. Such a double supply would, I imagine, be a grave objection to the scheme; and I do not think it very likely to find favour in London, though it might probably, as the author suggests, be used advantageously in some of our foreign stations where water is scarce or of bad quality.

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* See, for example, Plates 5, 10, and 12, in Appendix to Report.

Apart from Mr. Ormsby's, the projects stand as follows:—

Thames Basin Supply.—Mr. Bailey Denton,† Mr. Telford Macneill.‡

North Wales.—Mr. Bateman.§

South Wales.—Mr. Fulton.‖

Cumberland and Westmoreland.—Messrs. Hemans and Hassard.¶

Staffordshire and Derbyshire Hills.—Mr. Remington.**

It is obvious at the first glance that those schemes which propose to utilize the Thames basin have a great initial advantage. The strongest reasons ought to be shown to induce us to quit our natural watershed for a distant one, for the objections to such a change are manifold. In the first place there is the very important question of expense; and it needs no great consideration to perceive the probability that the farther we go from home the more we shall have to pay for the journey. Then, again, we have to look at the extent of the source of supply; for in a work of such magnitude it would be absurd to adopt a scheme which did not provide for a very great extension with the increase of population. The supply to be obtained from the Thames basin is practically unlimited, the enormous surface more than atoning for the rainfall being less than in mountainous districts. During the long drought of last summer the supply of water to the metropolis never fell short for a single day; and the London companies have reason with them when they point to the terrible scarcity that was experienced in many parts of the island, and, amongst others, in Manchester, during the prevalence of the dry weather. All the gathering grounds proposed for London are petty in comparison with the enormous basin of the Thames; and to be secure from the possibility of a short supply, reservoirs of vast size for the storage of storm-water would have to be provided. And, finally, it has been urged with great force that we are not justified, except in case of actual necessity, in withdrawing from the Midland Counties the supply which sooner or later may become of extreme importance to them.

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* 'A New Idea for the Water-supply of Towns.' Metchim & Son, Parliament Street. 1867.

† 'The Water Question: A Letter to the Earl of Derby.' London: Stanford, 1866.

‡ 'Water-supply of London by means of Natural Filtration of the Water of the River Thames.' London: Stanford, 1866.

§ 'Sources of the River Severn.' London: Vacher, 1865.

‖ Mr. Fulton has favoured me with a description of his scheme in manuscript.

¶ 'On the Future Water-supply of London.' London: Stanford, 1866.

** 'Engineering.'

Armed with arguments such as these come the proposals of Mr. Bailey Denton and Mr. Telford Macneill. I cannot, of course, follow the engineering details of these or any other of the schemes, and, indeed, feel considerable diffidence in describing them at all. In Mr. Denton's interesting letter it is suggested that, whereas it is impossible to prevent the fouling of rivers by sewage, a line ought to be fixed on each river above which its freedom from sewage-contamination shall be jealously preserved. To ensure a sufficient supply for London in the face of these precautions, storage reservoirs for the collection of the surplus water of floods must be provided, and an increase effected in the volume of the rivers by means of an efficient system of drainage. Such a system would, no doubt, supply us with *sewage*-free water; but it must be remembered that a great portion of the water would still be *drainage* water, arising in great part from cultivated land. It is perhaps rather less unpleasant to drink the exuviæ of cattle, sheep, and pigs, than that of human beings; but it must be distinctly understood that that is the only improvement suggested.

Mr. Telford Macneill proposes to draw the Thames water from the river at Teddington, and carry it back by an open canal to the Bagshot sands, where it would be subjected to a process of natural filtration, and would then be conducted by a covered conduit to a service reservoir at Norwood. He calculates that, with the addition of a certain quantity to be collected from the Guildford district, a supply of 400 million gallons per day of pure water could be provided in this manner, and that the supply so obtained would have the great advantage of being always cool. I cannot pretend to give an opinion on the merits of this scheme, which rest almost entirely on engineering questions. As to the question, whether such a gigantic filtration would be certain to remove all noxious matters from the water, that is a point which could not be decided off-hand.

Out of the four schemes which propose to draw the London water-supply from distant collecting-grounds, two (those of Mr. Bateman, and Messrs. Hemans and Hassard) have already been noticed in these pages. Mr. Bateman, it will be remembered, proposes to go to the sources of the Severn, and store up the water of the North Wales mountains in enormous reservoirs; while Messrs. Hemans and Hassard would impound and increase, by intercepting conduits, the waters of lakes Haweswater, Ullswater, and Thirlmere. Mr. Remington's scheme I am but imperfectly acquainted with, but Mr. Fulton's deserves a word of notice. He has selected, in the basin of the river Wye, in South Wales, a larger collecting-ground than either of the above-mentioned ones. He divides the gathering ground into four districts, having a total area of 440 square miles; the whole capable, he estimates, of supplying London with 393 million gallons per diem; but he proposes, in the first instance, to utilize only one of these districts, and to content himself with a daily supply of 130 million gallons. To guard against deficiency of supply, he proposes to construct impounding reservoirs in each district, capable of containing 150 days' supply. The water is to be conducted by a conduit, which shall pass near Bromsgrove, Warwick, Banbury, and Watford, to Totteridge, near Barnet, where service reservoirs will be constructed. The conduit will be 180 miles in length. The cost for a supply of 130 million gallons a-day, the conduit being large enough for 230, is estimated at 7,000,000*l*. The great merit of the scheme appears to me to lie in the thin population of the Wye basin and the absence of large towns on the line of the proposed conduit, which might claim a prior right to the gathering grounds.

With this meagre sketch of the present claimants for the honour of supplying London I must conclude. To the report of the Royal Commission we must now look for further light on the subject, with the hope that their labours will result in securing to London that priceless treasure—an unimpeachable and abundant water-supply. That is the object to be striven for; and the richest city in the world will surely allow no paltry motives of economy to prevent the attainment of that which is so essential to the health and well-being of her children.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

THE past quarter has been full of agricultural interest. Thanks to the Chambers of Agriculture throughout the country, and their central representative in London, farmers are gradually acquiring that share in the conduct of public affairs which properly belongs to their wealth, their numbers, and their importance. As every addition to power and self-respect quickly shows itself in material results, it is proper that a social development of this kind be noticed here. And though for the present the movement bears rather a political than a practical aspect, yet we shall, no doubt, soon find technical and professional advancement marching in equal step with political and social progress.

Turning now to the details of agricultural experience, we have to report that the severe drought of 1868, which resulted in the utter failure of the turnip crop, the complete stoppage for several months of all grass growth, and the provision of but a scanty crop of hay for winter use, has been followed by so mild and wet a winter that autumn-sown green crops (stubble turnips, rye, rape, mustard, and Italian rye-grass) have done much to meet the difficulties which the stock-owner had anticipated. And the smaller consumption of succulent food, and the larger use of straw cut into chaff, and mixed with meal or cake for cattle and sheep (whether in a fatting or ordinary "store," or a breeding condition), have at once kept the live-stock of the country in a more than usually healthy condition, and proved a useful lesson of economy for future seasons. An inquiry into the agricultural lessons of so unusual a season has shown that land-drainage is serviceable even in a drought—both directly by deepening and enlarging the storehouse of vegetable resource on which plants can draw, and indirectly by enabling a deeper, earlier, and more thorough tillage, which hinders the cracking of the surface, and thus the searching influence of dry weather.

It has also shown the advantage in farm practice of retaining for use seed-beds of plants, such as cabbages, capable of transplanting as soon as rain comes, and thus of furnishing the earliest possible provision against a scarcity consequent on the failure of ordinary crops. It has shown, too, the great injury done to farmers, and to agriculture generally, by a rigid system of rules laid down in agreements between landlord and tenant. Those who felt at liberty, whether as to the subsequent cropping of the land in consequence of a failure of the young clover plant, or as to immediate cropping to make up for a deficient mangold and turnip crop, to act as they thought best under the unusual circumstances, have been much better off than those who could do nothing out of the rule of rotation laid down to them without special licence from the owner or the agent.

The dry weather was a great aid to those who are interested in the promotion of sewage farming.

At the recent annual meeting of the Liverpool Sewage Utilization Company, Mr. R. Neilson, the chairman, gave some information as to the satisfactory progress of the company's works. The original intention of laying the main line to the Crosby Sands was prevented by obstacles over which the company had no control. They had consequently arranged with Mr. Blundell, of Ince, for a lease of 40 acres of excellent land, on which to develop the system, and advantageously supply the sewage to a number of the tenants of that gentleman and of Lord Sefton, who were anxious to take it. Seven and a-half miles had already been laid. The erection of the buildings of the pumping station was completed, the boilers were in their places, and the principal portion of the engines were already finished. The connecting sewer had also been completed from the well to the point of junction with the main sewer which received the sewage from all the upper parts of Liverpool and Everton, as far as Edge Hill, being that portion of the town where water-closets had been most generally adopted, and which would give a comparatively inexhaustible supply.

On Lodge Farm, situated near the market gardens around Barking, which were dried up and comparatively unproductive, enormous growths of cabbages, mangold-wurzel, and other succulent crops were obtained by three or four soakings with sewage in the course of the year; and unusual success also attended the use of sewage even for corn crops. A return of potatoes, grown with sewage, was obtained, equal to 50*l.* an acre: cabbages, sold for 20*l.* an acre, and stubble turnips, sold for 11*l.* an acre, were grown during the autumn months. Five and a-half quarters of wheat, taken after the wheat crop of 1867, on poor gravelly soil, were obtained by the use of two dressings of sewage; and heavy crops of rye and winter oats were also grown. Around Salisbury, and in other water-meadow districts, the value of summer irrigation was seen, and farmers who owned any water-meadow had an immense advantage over their burned-up neighbours.

As another feature of the season, we have to mention the successful commencement of the sugar-beet cultivation in this country.

Analyses have proved that our sugar-beets of 1868 have contained 9 per cent. of sugar, which is rather more than those of Dutch growth: and roots grown with sewage at Lodge Farm yielded over 13 per cent. to Dr. Voelcker. Mr. Duncan's factory at Lavenham has begun work. Eight hundred tons have been grown for him by the Suffolk farmers; and contracts have been completed to supply six thousand tons next year; and there is every prospect of the industry being established at other points. At a recent meeting of the West Suffolk Chamber of Agriculture, Mr. Duncan said that the prospect of a satisfactory establishment of the beet-sugar manufacture in England now is greater than it has ever been, for in Cuba—which alone has hitherto supplied us with as much sugar as all the beet-sugar of the Continent—the abandonment of slavery is imminent; and this will, no doubt, so diminish supplies as very materially to raise the price. Moreover, the industry is not by any means an exhaustion of the soil. Sugar-beet does not exhaust the land, even so much as mangold-wurzel growing. A small root, with a small percentage of ash is desired: and as it is the ash alone which the plant takes from the soil, that will for the most part be returned to it in the compressed cake of pulp which is sent back from the factory to the farm.

Turning now to another subject, we find from Dr. Voelcker's report to the English Agricultural Society, that four hundred and thirty-two analyses of manures, and cattle food, made in 1868, indicate the general excellence of the superphosphates supplied to English farmers last year. Compound artificial manures, on the other hand, which are generally manufactured on a basis of spoiled guano, were inferior and dear. Sulphate of ammonia has increased in use for other purposes than those of English agriculture, and has thus risen enormously in value. The coprolite beds of Suffolk and Cambridgeshire are gradually becoming exhausted. Large quantities of Sombrero rock, and of the recently discovered phosphorite of the valley of the Lalm, in Nassau, have been imported.

The immense demand for artificial foods has given a greater impetus to the adulteration of oilcakes. Among other newly introduced cattle foods is "Nutritious cocoa extract." "Theobroma," the generic name of the plant, signifying "food for gods," has long since proved an agreeable food for man, and it is quite possible that some of the coarser refuse part of the seeds from which the cocoa of the breakfast table is obtained may yield a wholesome food for beasts.

Among the more important points in Dr. Voelcker's report is the scarcity of sulphate of ammonia. M. Ville, of Paris, has lately made known the fact that salts of ammonia are found in large quantities in some of the Tuscan lagoons. This fact had, indeed, been already fully investigated and published by M. Becchi, a distinguished Italian chemist and mineralogist, who in 1853 described a mineral known as "Larderelliti," named after the proprietor of the estate, and containing a considerable percentage of ammonia. A large block of this mineral, which is a borate of ammonia, was shown in the International Exhibition of 1862. Since then M. Becchi has continued his researches, and obtained by the recrystallization of the residual salts left when some water from a lagoon at Travale was evaporated, a sample of ammoniacal mineral, containing no less than 80 per cent. of the pure salt. The announcement of such a fact as this is a very important point in the recent history of agriculture; and, though an Italian discovery, it will very soon tell upon English fertility.

Coming home again, we have to report the activity of our local farmers' clubs, on whose operations, as well as on imported fertilizers, English fertility very materially hinges. The subjects of deep cultivation, steam culture, live-stock management, dairy farming, the increase of home-meat production, the condition of the labourer, the serviceableness of benefit societies on his behalf, the best way of dealing with pauperism, the relations of railways and agriculture, have been thus discussed. And it is not only the strictly Agricultural Society which thus benefits the farmer. The Society of Arts has interested itself in, among other agricultural topics, the provision of contrivances for the safe transit of milk and meat by railway. And, in competition for its prizes, some thirty or forty devices have been exhibited, more or less simple and efficient, out of which, probably, some improvement may arise in the present very imperfect arrangements by which so large a proportion of the food of the metropolis now reaches the consumer.

From the annual returns of the Board of Trade, giving the agricultural statistics of the years 1867 and 1868, it appears that a considerable increase took place last year in the area under wheat, and a diminution under all other grain crops. There was an increase in the area of the potato crop, and a diminution under all other green crops. An increase in the number of cattle and sheep was returned, and a diminution in the number of pigs.

2. ARCHÆOLOGY (PRE-HISTORIC),

And Notices of Recent Archæological Works.

MR. G. V. DU NOYER, late of the Geological Survey of Ireland (whose death we regret to record), communicated a paper last year to the Geological Society,* "On Flint Flakes from Carrickfergus and Larne." These worked flints (a series of which is placed in the

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* Which appears first in the list of postponed papers published in the February number of the Society's Journal, p. 48.

Museum of Practical Geology, Jermyn Street) were picked up by the author from the gravelly drift and subsoil clay of the north of Ireland, in Antrim and Down. Mr. Du Noyer describes the method of forming the flakes, and points out that they appear to belong to two different periods, *viz*:—1. In the drift-sand and gravel which skirt the shores of Belfast and Larne Loughs, in the Co. Antrim, and the coast from Holywood to Donaghadee in the Co. Down, about 20 feet above high-water mark. These are rude in form and are always oxidized on the surface, and are often much abraded. 2. In the subsoil clay at all elevations up to 600 feet or so, on the northern slopes of Cave Hill at Belfast, the Common of Carrickfergus and the high-ground around Larne Lough, and the Island Magee, they often occur in groups so that hundreds can be collected over a surface of fifty square yards, and their appearance is fresher than the littoral specimens. In Island Magee they would appear to have manufactured some, judging by the hoards found. Mr. Du Noyer considered that the great abundance of flint-implements in this region was due to the aborigines seeking the natural outcrop of the chalk to obtain the raw material; he further suggests that the leaf-shaped flint-flakes of this second epoch (found in the bed of the river Bunn) were known and used by the earliest of the historic races in Ireland, and by them worked into those delicately-chipped and symmetrically-formed winged arrow-heads, spear and javelin heads which are found so often, associated with rude pottery, beads of amber, glass, and shells, in the sepulchral tumuli and megalithic chambers of Ireland.

In Mr. Bauerman's paper on Arabia Petræa,* he gives an account of the ancient Turquoise-workings in the Wady Maghara, which, although much encumbered by cliff-falls at the outside, are for the most part accessible for a considerable distance from the surface, and in many instances the old faces of work can be seen. These are covered with small and irregular tool-marks, of such a character as to leave no doubt that they have been made with flint-flakes, great numbers of which are found strewing the valleys and hill-sides, as well as within the workings themselves. Most of these flakes are of a triangular or trapeziform section, brought up to a point, which is generally well-worn and rounded, and the shape of which, when blunted, corresponds perfectly with the grooves on the face of the rock. In one of the smaller caves, carefully examined by Mr. J. K. Lord, the floor was covered to a considerable depth with a coating of impalpable dust, which, when disturbed, rose in suffocating clouds. On sifting this, numerous fragments of stone hammers and pieces of wood, some partially carbonized, but which had evidently been fashioned into tools, were found.

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* Also in the February number of the 'Quart. Journ. Geol. Soc.'

The latter form segments of cylindrical blocks, with roughly conical points (that have evidently been shaped with a blunt, or imperfectly cutting tool), with a thickened head, notched round underneath as if to receive a withe or cord. The head bears evident marks of having been subjected to repeated blows. Although only a single segment in any degree of perfection was found, there can be little doubt that these were used as mountings for the flint chisels employed by the ancient miners. Without something of the kind it would be difficult to work with the flakes, owing to their tendency to break across when not struck fairly on the top.*

The hammers found in the workings were mostly of a very rude kind; in many cases rough natural fragments of dolerite, taken from the flow capping the adjacent hills, have been used, only a pair of holes on opposite sides, produced by the action of sand pressed upon the surface by the thumb and forefinger, being apparent. Some, however, show a little more work, having a groove, to receive a withe handle, cut round them, like the so-called Aztec hammers found in the aboriginal workings in the Lake Superior Copper Mines. Most of them are broken at the ends, and can only be regarded as spoiled or waste tools. The same holds good with regard to the wooden fragments and flint-flakes. Tablets cut on the face of the rock show these workings to have extended from the 3rd to the 13th Manethonian dynasties, corresponding to an interval of about 1600 years.

Captain F. von Koschkull, writing on the Caucasus,† mentions that, being engaged in a survey of the Salt-district in 1865, he had his attention attracted by some old mines which were regarded by the inhabitants as natural caves. (The principal beds of rock-salt, we should state, are in the valley of the Araxis, both east and west of Mount Ararat, and geologically are of Lower Tertiary age.) Captain Koschkull soon satisfied himself of their being the work of man, and resolved to explore them. At first his guides would fain have dissuaded him from carrying the plan into execution, as their imagination had peopled all these subterranean passages with evil spirits, of which they stood in bodily fear. Disregarding their superstitions, the Captain penetrated one of the ancient adits, and partially explored what proved to be a very extensive and fairly-well-wrought mine, evidently of great antiquity. At the remote end of one of the galleries he found heaps of mined salt, and hundreds of tools of various forms and sizes, either perfect, or more or less worn and broken. These implements consisted for the most part of picks or pick and hammer combined, and varying from 5 to 15 inches in length, wrought with great labour and considerable skill out of a tough hornblendic rock. None of these tools were pierced for the insertion of handles, but all were encircled by grooves for the reception of withes or thongs; in this, as in the character of the material of which they were formed, resembling many of the stone implements of Europe, and being apparently the product of the same age, or more accurately speaking, of the same stage of intellectual development. The same author mentions that in the mountains of Karthli-Imeritia are excavated ("troglodyte") houses, and an entire city has been discovered, wrought out of the rocky walls which border the narrow valley of the river Ljokhwa, an affluent of the Kur. He was also present and assisted (in 1864) at the opening of two royal tombs which had been found in one of two tumuli, called the twin tumuli, situated upon the peninsula of Taman. They proved to be of Greek origin, and contained two sarcophagi of cypress wood, carved and gilded. The contents of the sepulchral vault were very rich and varied, and belonged to a period of high art and civilization.

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* A gentleman present when this paper was read (we think Dr. Murie), suggested that it was more probably a tent-peg, such as the Arabs use for driving into the ground to secure the border of the tent.

† Silliman's American 'Journal of Science and Art,' vol. xlvi., p. 336.

Early in September last, in making excavations for a sewer at Trowse, near Norwich, a number of oak piles were discovered by the workmen, driven into a bed of compact river-gravel, 7 feet beneath the surface, and covered by 3 feet of peat, containing fresh-water shells and abundance of bones; but no flint or other implements were met with. The evidence is too scanty to form any positive conclusion upon; but in this broad but shallow valley, before the peat accumulated, it is suggested the piles stood in the water, and formed the base of a pile-work habitation, from which the large quantity of bones were thrown into the water. The animals identified were sheep, horse, deer; so plentiful were the bones that the navvies sold them by bushels to the dealers. Owing to the nature of the contract, the trench was again refilled within forty-eight hours from the discovery being made, and so all further search was stopped. If the site of a habitation, it must have been at a *comparatively late period.*

In the 'Journal of the Proceedings of the Essex Institute,'* Salem, Massachusetts, Mr. F. W. Putnam gave an account of the exploration of several Indian shell-banks at Goose Island, in Casco Bay, and at Ipswich. Many relics were found of great interest to the archæologist.

He also exhibited a series of Indian stone implements, found in Essex county, consisting of axes, tomahawks, gouges, arrow-heads, and many others to which no accurate name could be given. Some he considered were "sinkers," from their being found on the shore at Swampscott, and other places, and they seemed from their form well adapted for sinking a fish-net.

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* Vol. v., No. viii. Dec., 1868.

There were several stones of a flattened oval form, and others nearly round, all having a groove cut round them: also some flat, smooth stones, with two holes bored through them, perhaps used in the process of rope-making to twist strips of skin or bark together. Besides these were some stones of very perfect finish and of various shapes, but all provided with a hole through the thickest part; in blowing into which (as one does into a key) a loud call or whistle could be sounded. Mr. C. Cooke gives a description of an Indian burying-place in Essex county, containing six skeletons, lying from 18 inches to 2 feet beneath the surface, and placed in a row north and south, 5 feet apart, save two, which were within 18 inches of one another. Beneath each skeleton were placed three flat pieces of red sandstone—a rock not found in this region—one piece beneath the head, another near the middle of the body, and the third under the feet. All the skeletons were in the same position; namely, lying on their left side, with their faces turned to the west, the hands under the head, and the knees drawn up against the chest.

M. Roulin laid before the Academy of Sciences* a report on a series of stone implements from Java, collected and forwarded, by M. Van de Poel, of Cheribon, as a present to the French Government. The collection comprises thirty-nine articles of polished stone, which were successively dug up from great depths in the soil. They belong to a period antecedent to all the records and traditions of the country. It is difficult to obtain any from the natives, owing to the adoration they profess for them. The specimens differ in general aspect from any already in the possession of the Academy; they are remarkable for the beauty of the materials out of which they have been shaped, and for the symmetry of their form. They vary in size from 385 millimètres in length to only 26 millimètres; these being the two extreme measurements. Owing to the want of any information relating to the mode of occurrence of the specimens, the report is confined to their direct examination, and the comparison of them with analogous modern objects. Nearly all of them belong to implements of labour; there are, besides, three bracelets and a thin plate of oval shape, probably "*destiné à une incrustation*," which from their style of workmanship are evidently to be associated with the other specimens. There is a very striking absence of all kind of arms. It is impossible to suppose that the ancient Javans were entirely wanting in weapons of warfare or of the chase; but perhaps these were made of wood, like those now used over a large portion of Polynesia. Under ordinary circumstances it does not require many years to efface the traces of such arms. Still, some vestiges would have escaped destruction, and they will, when discovered, become the objects of much interest. Fifteen only of the thirty-five implements are entire, but some of the others, though not perfect, are of great importance. One of these latter, made of a greyish flint, formed part of a strong blade 25 millimètres in thickness, smooth beneath, slightly convex above, of a uniform width and thickness (82 and 25 millimètres respectively). Its length, which at first must have been—so far as we can judge by its other dimensions—from 12 to 15 centimètres, is no more than 8; in this state it was still large enough to be made useful, and by the following expedient:—It was necessary to make a new edge, and it was first cut square. This was performed by two saw-cuts made on the opposite faces, and continued so as to nearly meet, the separation having, however, been finished by fracture. The stone appears to have been attacked first on the convex side, which is more deeply cut, and, strange to say, the depth of the notch is likewise convex. This cutting or sawing may have been performed in a manner similar to that practised by the inhabitants of St. Domingo, and their neighbours on the adjoining continent, as recorded by Oviedo, who visited the country in 1513. With sand and a thread of *cabuia* or *henequen* (two species of agave) they can cut iron. They make use of the thread as we should of a saw, drawing it alternately from right to left, during which they move about and rub quickly against the iron very fine sand, which they have previously spread along the passage. Some of the other specimens have been cut in a similar manner. In the majority of the Javan specimens the edges are square, and the thickness nearly uniform—features that are characteristic of the Scandinavian celts. The implements seem all adapted for cutting wood. Some of the heavier specimens must have needed both the arms of a strong man to wield them, and they probably were used for chopping down trees, whilst the smaller tools, which could be used with one arm, were intended for more delicate work. All have been shaped on a similar plan. They offer in general a single cutting-edge formed at the expense of the lower face, which is even, or slightly concave, like our modern adzes. They have been formed from flint, chalcedony, jasper, porphyry, aphanite, sandstone, &c. The report is illustrated with a plate, representing an adze from the Isle D'Oualan (Carolinas), and an ancient implement found in Egypt, which are very similar to the forms from Java, described by M. Roulin.

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* 'Comptes Rendus de l'Acad. des Sciences.' Paris, 28 Dec., 1868.

Mr. Woodward read a paper before the Geologists' Association on "Man and the Mammoth; being an Account of the Animals found associated with early Man in Pre-historic Times."* The author gave an account of cavern-explorations and their results; the progress of discovery in the Quaternary deposits; the proposed order of chronological sequence of the various remains found in river-gravels, peat-mosses, kitchen-middens, caves, crannoges, *pfahlbauten*, &c.; of the animals found, whether migrated, extinct, now living, or having been killed off by the hand of man.

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* The lecture has since been published *in extenso* in the 'Geological Magazine,' February, 1869, p. 58.

He pointed out that widely different states of civilization (as at the present day) might then have existed in close proximity to each other, and suggested that the old cave-dwellers of Perigord represented the population of the less civilized portion of the globe, as the aborigines of Africa, America, and Australia do now in our own day.

ETHNOLOGICAL SOCIETY.

The Ethnological Society have resolved to institute a permanent committee (upon a scheme proposed by Col. Lane Fox, Hon. Sec.), for the purpose of examining into the validity of all evidence submitted to the Society, or otherwise obtainable, in relation to the science of man. To assess the relative value of such evidence, whether direct or second-hand, and to record the names of the authors or communicators according to a scale to be hereafter determined upon. To decide on a fixed terminology, and to classify all facts admitted in evidence. The classification to include the following primary divisions:—1, Races; 2, Languages; 3, Religions; 4, Folk Lore and Superstitions; 5, Laws, Customs, and Institutions; 6, Works of Art and Industry.

Another part of the scheme is the distribution of skeleton maps of various sizes for the purpose of marking the geographical distribution of the several classes. Distributions arranged by individual members will be discussed by the Committee, who will from time to time report to the Society the progress they make. Registers will be kept which shall be available to any member of the Society desiring to consult them. Such a scheme, if carried out successfully, is likely to result in a rich harvest of materials on which, at a future day, sound generalizations may be based.

ANTHROPOLOGICAL SOCIETY OF LONDON.

A paper was read on the 2nd of February, by the Rev. J. G. Atkinson, on the "Cleveland Gravehills." The moorland districts of the valley of the Esk, lying to the west of Whitby, at between eight and sixteen miles distance, are thickly studded with burial mounds or barrows, or in the old Danish vernacular, "howes." Many have been destroyed; but of the larger ones which yet remain, a large proportion have been examined by the author. He obtained forty-five urns and evidence of more than one hundred interments after cremation, but not any trace of metal. In some of the larger mounds, evidence appeared of three successive interments: first, in the centre; the second, inserted at a distance from the centre, and rudely and violently misplaced to make room for a third, due to an intrusive, perhaps a conquering tribe. The author was of opinion that the whole of the remains belonged to an extremely remote period.

Mr. Edward Peacock, F.S.A., described the opening of a barrow at Chatham, Lincolnshire. The approximate dimensions of the mound were 114 feet by 75 feet, with a central depth of 9 feet 6 inches. Three interments were discovered: one in the centre; another at 42 feet south (of a youthful subject), and another at 40 feet north of the centre; all accompanied by urns of a Celtic type. The work of excavating was particularly interesting, as showing the manner in which these mounds were constructed, the materials being carried in baskets or panniers; each basketful of sand could be distinctly traced.

3. ASTRONOMY.

(*Including the Proceedings of the Royal Astronomical Society.*)

At the General Meeting of the Astronomical Society on February 12th, it was announced that the gold medal for the year had been awarded to Mr. Stone, of the Greenwich Observatory, for his labours towards the determination of the sun's distance. We have already had occasion to refer at intervals to the various papers which Mr. Stone has written upon this subject; and a reference to the accompanying review of the proceedings of the Astronomical Society will show that he is still engaged on the same interesting work. What he has done may be divided into two sections: first, independent solutions of the problem of determining the sun's distance; and secondly, the careful re-examination of the observations and calculations of others. He has detected numerical errors in the processes of Leverrier and other mathematicians, besides errors of interpretation in the work of those who investigated the transit observations made in 1769; and he has given a large share of attention to the consideration of the proper means of weighing discordant observations,—a question of great difficulty, which largely enters into the problem of determining the sun's distance. The result of his labours has been to show that the sun's equatorial horizontal parallax is probably about 8″·91; his distance, therefore, about 91,700,000 miles.

Major Tennant's account of his work during the great eclipse of August last, had not led us to form very hopeful expectations respecting the photographs taken by his party. Fortunately it has turned out that these photographs were much better than Major Tennant had supposed. Mr. De la Rue suggested that it would be advantageous to take enlarged pictures of the photographs on glass, and to etch them according to the plan which he had used for the eclipse of 1860. In reference to this suggestion, Major Tennant wrote to Mr. De la Rue, that "the large pictures were thin and poor, and there was no use in treating them by etching; for the real thing would be better shown by a distribution of transparencies, so as to make them generally accessible." Accordingly Major Tennant sent eight sets of transparent copies on glass of his eclipse pictures to the Astronomer-Royal for distribution. One of these sets has reached Mr. De la Rue's hands. He says of them —and no one is better able to judge — "they are extremely interesting, and must be considered as eminently successful results." They contain much more detail than can be seen in the paper copies.

The two most important features exhibited in Major Tennant's photographs are: first, the spiral conformation of the Great Horn, marked A in the drawings (the only prominence which was visible *throughout* the totality); and secondly, the well-defined elevations indicated by a soft light, altogether different from that of the red prominences. "These entities," says Mr. De la Rue, in reference to the fainter light, "bounded by outlines which blend almost imperceptibly into the general light of the corona, are deserving of especial study, which will be best accomplished by means of photography, as it truly records their faint contours, which are likely to be overlooked in eye observations, because they are lost in the softened light which surrounds the moon, and also because the eye is naturally attracted most by the prominences which have a distinct outline."

It appears that the alterations which have taken place in the nebula round η Argûs are not nearly so important as Mr. Abbott's papers had seemed to indicate. In a letter sent to Sir John Herschel on this subject, Lieutenant Herschel (his son) remarks that the nebula is not only a very difficult object to draw properly, but that its appearance varies under every change of illuminating and magnifying power or of atmospheric conditions. He has carefully marked down the place of every conspicuous star in the nebula, and Sir John Herschel finds no difficulty in identifying all of these stars (except one small one) with those he had himself mapped down when at the Cape. Again, it is clear from Lieutenant Herschel's drawings that the closed lemniscate vacancy seen by Sir John Herschel thirty years ago, has not been replaced by a vacancy extending along two perfectly open channels to the boundary of the nebula. On the contrary, a closed figure is shown in the drawings just sent, which, though not agreeing exactly with the older drawings, yet presents no difference which may not fairly be ascribed to the effect of using so much smaller a telescope in the recent observations. On the other hand, there is no doubt that the visibility of the nebula has largely increased in recent times. Lieutenant Herschel says that the eye catches the nebula as readily as the Pleiades. When Sir John Herschel was at the Cape the nebula was not visible to the naked eye. We can hardly suppose that so remarkable a change as this can be wholly due to the diminution of η Argûs from the first to the sixth magnitude. This variation might certainly enable the eye to recognize a nebulosity before invisible, but it could not bring out the nebula as a distinctly marked object.

Mr. Huggins has succeeded in seeing the red prominences round the sun by the aid of coloured glasses having the power of absorbing nearly all rays, except those belonging to the red part of the spectrum in which the C line of the prominences is found.

NOTICES OF THE ASTRONOMICAL SOCIETY.

Mr. Tebbutt supplies a paper on the Solar Eclipse of August 18th last, as observed at Windsor, New South Wales. At that place only about one-third of the sun's diameter was eclipsed.

Mr. Huggins refers to observations which he had made during the past two years for the purpose of obtaining a view of the red prominences seen during a solar eclipse. The report of his observatory refers to the fact that the spectra of the prominences should be visible if those bodies are gaseous. He goes on to describe the contrivances by which he attempted to isolate portions of the spectrum. It appeared to him highly probable that if the parts of the spectrum which remained after certain portions had been absorbed were identical with those in which the bright lines of the flames occur, these objects would become visible. But as he had no knowledge of the position of the bright lines in the spectrum, "it would have been only by accident," he remarks, if he had succeeded. We have seen elsewhere that he has now succeeded in making the prominences visible by this method.

The same idea appears to have occurred to Lieutenant Herschel, who communicated his views on the subject in a letter to his father, Sir John Herschel. The letter remarks that this suggestion shows how immediately and readily a clearly-defined new fact suggests to an active and combining intellect the possibility of immediate practical application. "If I mistake not," he adds, "the double discovery made by Mr. Lockyer and M. Janssen, of a mode of rendering the prominences *sensible* (not visible) turns on the same feature."

Mr. S. Newcomb discusses Mr. Stone's rediscussion of the transit of Venus in 1769. He endeavours to show that Chappe cannot be assumed to have observed an apparent internal contact of Venus instead of the real one, or "the formation of the black drop" as it is termed. Certainly, Chappe's words are not clear. After describing the undulating appearance of both the sun and Venus, he goes on to say,—"A ce premier contact Vénus s'est allongée plus considérablement que le matin, en s'approchant tout-à-coup du bord du soleil." One might interpret this to signify that the elongation of the disc (the pear-shaped figure it assumes) was more remarkable at the egress than at the ingress; or that the sudden leap, so to speak, by which the edge of the planet's disc is carried forward to that of the sun's, covered a greater range than the corresponding phenomenon (reversed) at ingress. Mr. Stone takes the passage to signify that the elongation ~~was~~ of a more complete kind, so that a *broader* (not a longer) connecting-band was seen; in other words, Mr. Stone holds that Chappe missed the formation of the narrow ligament owing to atmospheric undulations, and first saw some phase much nearer to the apparent internal contact. Weighed by results, Mr. Stone's view has clearly the advantage over Mr. Newcomb's. As Mr. Stone remarks, "If the observer's words are doubtful, and we find that by assuming he observed an apparent contact all the observations are rendered accordant, whilst by assuming that he has observed a real contact all the observations are rendered discordant, it is not only permissible but necessary that we should assume that apparent contacts were observed.

Mr. Stone draws from the results of the observations made at Greenwich upon the transit of Mercury in November last, that the three following points should be carefully attended to in future observations of the more important transits of Venus:—

1. That telescopes of nearly the same aperture should be employed.

2. That very nearly the same magnifying powers should be employed by all the observers.

3. That attention should be directed to observations of real internal contacts as the chief points.

The words "real internal contacts," it is to be observed, refer to the formation of the black drop, which is undoubtedly simultaneous with the true internal contact of the planet's limb with the sun's.

Mr. Stone has extended to 1867 the calculations he had made respecting the constant of nutation, as determined from the observations of the pole-star with the transit-circle of the Greenwich Observatory from 1851 to 1865. Taking these observations, thus extended, in combination with those made upon Cephei 51 and δ Ursæ Minoris from 1851 to 1865, he obtains for the final value of the constant of nutation

$$9''\cdot 134 - 0\cdot 55\, p + 2\cdot 02\, \delta p + 0\cdot 29\, \delta m - 0\cdot 6\, \delta c.$$

where p, δp, δm, and δc are the possible errors in the assumed estimates of the proper motion of the pole-star in R. A, and N. P. D, and of δ Ursæ Minoris, and of 51 Cephei in N. P. D. respectively. On account of the bearing of the constant of nutation upon our estimate of the moon's mass and of the sun's distance, these investigations are of extreme importance.

The Astronomer-Royal has supplied another of his valuable papers on the preparatory arrangements which will be necessary for the efficient observation of the transits of Venus in the years 1874 and 1882. It is almost impossible fairly to represent the nature of the present paper in the brief space available in these pages. Indeed the eight octavo plates which accompany the paper, and the two which illustrate Mr. De la Rue's paper on the same subject, are very necessary to the proper interpretation of Mr. Airy's remarks. But while referring the reader who would thoroughly master the views presented in these admirable essays to the papers themselves, we may point to the following important conclusions derivable from Mr. Airy's calculations:—

1. For observing the ingress of Venus as accelerated by parallax (in 1874), Owhyhee and the neighbouring islands, the Marquesas Islands, the Aleutian Islands, and the mouth of the Amoor are more or less favourably situated.

2. For observing the ingress retarded by parallax, Kerguelen Island and Crozet's Island are well situated though geographically unfavourable. Next in order come Rodriguez, Mauritius, and Bourbon Islands, Madras, and Bombay.

3. For observing the egress accelerated by parallax, a part of the Southern Continent if available would be the best place. Passing this region over, we come next to the Auckland Islands, Canterbury, Wellington, and Auckland, Norfolk Island, Melbourne, and Sidney.

4. For observing the egress retarded by parallax, Omsk, Orsk, Astrachan, Erzeroum, Aleppo, Smyrna, and Alexandria are well situated.

All these cases refer to the transit of 1874. As regards the transit of 1882, it is noteworthy that there is a possibility of applying the same method as was employed in 1769,—that is, determining the sun's distance from the different duration of the transit as observed from different points of the earth's surface. This method, Mr. Airy remarks, fails altogether in 1874, and there is not much prospect of its being successfully applied in 1882. Both these transits take place in December, when the southern or sea-hemisphere of the earth is turned towards the sun. The transits of 1761 and 1769 took place in June, when the northern hemisphere was bowed towards the sun. Hence, principally, arises this important difference between the approaching pair of transits and the pair observed last century.

Failing observations on the duration of the transit in 1882, the accelerated and retarded ingress, and the accelerated and retarded egress, may be respectively observed from the four following sets of stations:—

1. Kerguelen, Crozet's, Bourbon, Mauritius, and Rodriguez Islands.
2. Every city near the seaboard of the United States, and every important city of Canada, also Bermuda, Jamaica, and the West Indian Islands.
3. The stations mentioned under 2, and the coast of South America from the Isthmus of Darien to Rio Janeiro.
4. Parts of the Antarctic Continent, Sydney, Melbourne, and parts of New Zealand.

If the durations of transits are to be observed, then certainly portions of the Antarctic Continent will have to be selected. Captain Richards, Captain Toynbee, Rear-Admiral Ommanney, and Staff-Commander J. E. Davis, supply some remarks on the geographical difficulties to be encountered in finding stations in high southern latitudes, but the examination of their papers would lead us away from astronomical considerations.

Mr. De la Rue gives an interesting paper on the possibility of taking photographs of Venus in transit. If this were done at several well-separated stations, it seems clear that a most important auxiliary means of estimating the sun's distance would be afforded. Mr. De la Rue points out that the close correspondence between the results obtained by micrometrical measurements applied to his eclipse-photographs in 1860, and the elements calculated by Mr. Farley, of the 'Nautical Almanac' office, show that a very close approximation to the truth is to be looked for in the case of the transit of Venus. For the difficulty of measuring the solar and lunar discs presented in an eclipse-photograph is very much greater than that attending the corresponding measurements in the case of a transit-photograph. And moreover, the observer of a transit would not be hurried like the observer of an eclipse, since the former phenomenon is several hours in progress, while the latter lasts but a few minutes.

Mr. De la Rue deals with the optical and physical corrections which would have to be made, showing how the distortion due to the optical peculiarities of the telescope could be determined beforehand, and suggesting that the experiments which appear to show that the collodion in drying shrinks only in the direction of its thickness might be repeated if any doubts still remain as to their correctness.

He remarks in conclusion, "No difficulties exist in photographing a transit of Venus; the operations are quite the same as those practised daily at the Kew Observatory; no strain on the nerves would occur as in the anxiety consequent on the desire of rendering available every moment of the short duration of a solar eclipse. All the operations could be conducted with that calm so essential for such a problem as the determination of the solar parallax, and I feel confident in recommending that timely steps should be taken to secure photographic records of the transits of Venus in 1874 and 1882."

A paper by Mr. A. Marth draws attention to the observations which should be made upon Mars during the present opposition. His calculations respecting the presentation of the planet correspond closely with those on which we founded the views of Mars which appeared in our last Chronicle. Mr. Marth invites observers to send in any drawings they may make or have made of Mars, in order that they may be arranged in the order of their areographical longitudes and latitudes. He proposes so to combine them as to form a new map of Mars. We have very little hope that any ordinary drawings will throw much new light on the conformation of the Martial continents and seas. Those of Mr. Dawes are so far in advance of anything that has yet been attempted (so far at least as fullness of detail is concerned) that little seems to be promised by the examination of inferior drawings. What seems more hopeful is the fact that new and larger telescopes are now being directed to the examination of Mars by well-practised observers. Amongst others we may mention Mr. Browning, who is now observing the planet on every favourable night with his fine 12-inch reflector.

Professor Kirkwood remarks respecting the meteor-shower of November last, that its duration was much greater than that of former showers. "As seen in Europe in 1866, and in America in 1867, the display was limited to three or four hours. Last November, however, it commenced on the night of the 12th, and had not ceased at daylight on the morning of the 14th. This would indicate considerable irregularity in the thickness of the stream." Regarding the meteor-zone as in a sense the tail of Tempel's comet (Comet I., 1866), we can understand the peculiarity here referred to, as corresponding to the expansion of the visible tails of comets, with increased distance from the nucleus. Doubtless in a few years this expansion will have attained such an extent, and the meteors will be so far apart, that there will be properly speaking no shower, though meteors will continue to be comparatively plentiful on the nights of the 12th, 13th, and 14th November.

Mr. Birt discusses at considerable length the subject of the Lunar Crater Linné. From the drawings made at different times by Messrs. Huggins, Noble, and Tacchini, he has estimated the dimensions of the cone, crater, and orifice of this interesting object. He remarks that these estimates must be received as approximations only, serving rather as a guide to observers than as being expressions of the exact state of Linné at the present epoch. Those who see in the varying appearance of Linné a proof of the activity of lunar volcanoes in the present day, should study the researches of Mr. Birt on the probable configuration of the crater.

Mr. Kincaid suggests an ingenious mode of constructing an automatic transit instrument. The apparatus consists of a plane mirror and a burning-glass, to be adjusted in such a manner that, at the instant the sun reaches the meridian, the rays ignite a thread which burns without smoke or residue; this releases a detent, and a motion is thereby given to the hands of the clock, bringing it to the correct local mean time. There is a supplementary arrangement by which if the thread should not ignite, in consequence of a passing cloud, at the instant of the transit of the first limb, the subsequent ignition of the thread will not affect the clock.

Mr. Lockyer, in a note on Mr. Huggins's paper "On a possible Method of viewing Red Flames without an Eclipse," writes to show that he was not aided by the eclipse observations in seeking for the prominence-spectrum. Unless Mr. Lockyer claims credit for the discovery of the gaseity of the prominences, apart from the credit due to him for his share in the discovery that their spectrum can be seen without an eclipse, we cannot see how Mr. Huggins's mistake (assuming it to be such) at all affects the proper apportionment of recognition in the matter of recent solar discoveries. The eclipse observers clearly deserve all the credit due to the first-mentioned discovery, which had been fully discussed in England for two months before Mr. Lockyer examined the prominence-spectra. It is impossible to undiscover the discovered. On the other hand, no one has disputed the claim of Janssen and Lockyer to the discovery that the prominence-spectra can be seen without an eclipse.

Professor Brayley supplies an interesting paper on the relation of the luminous prominences to the faculæ of the sun. He shows that there is strong reason for supposing the faculæ and prominences to be identical, or at least that the latter are the superior terminations of the former.

Some very singular facts connected with the mean distances of the asteroids and the commensurability of their periods with that of Jupiter are pointed out by Professor Kirkwood. He shows that wherever there is a wider gap than usual between the asteroids (considered in the order of their distances from the sun), that gap invariably corresponds with such values of the mean distance as would give a period having some simple association of commensurability with the period of Jupiter. It is well known that any such association would result in disturbance, and Professor Kirkwood argues that the particles which, on the nebular hypothesis, would have occupied these vacant zones, must have been so disturbed by Jupiter, as to adopt eccentric orbits, and so come into collision with exterior or interior particles. Even if this did not happen, the disturbance of their orbits would lead to a change of period and so of mean distance. Either result serves to account for the gaps in the asteroidal zone. He considers that very strong evidence is afforded by these coincidences (which certainly cannot be looked upon as accidental) in favour of the nebular hypothesis. He goes on to examine the Saturnian rings, which he remarks have been quoted in Proctor's Saturn as furnishing strong evidence of the nebular hypothesis of Laplace. He shows that the great division between the rings corresponds exactly with that portion of the width of the system where the particles would move in periods commensurate with those of the four inner satellites. The coincidence is certainly most remarkable. The whole paper is well worthy of careful study, being founded on well-established mathematical principles, and serving to bring together and account for a number of remarkable relations in the solar system.

Mr. Stone supplies a paper upon Aboul Hhassan's catalogue of 240 stars, which he shows to have been derived from Ptolemy's catalogue, and not (as Delambre had supposed) from Arzachel's. It is known that Ptolemy derived his catalogue from that of Hipparchus by applying an erroneous correction for precession. Mr. Stone shows how this fact may have led to the Arabian notion that the precessional motion is oscillatory. "If this view be correct," he says, "Ptolemy's want of candour respecting the nature of his catalogue is thus found to be throwing astronomy into complexities more than 1100 years after his death."

4. BOTANY, VEGETABLE MORPHOLOGY AND PHYSIOLOGY, AND ECONOMIC BOTANY.

Sterility of Hermaphrodite Flowers.—Mr. Thomas Meeham has observed that the flowers of *Epigœa repens* are practically diœcious —since the hermaphrodite flowers are sterile. He is led to speculate upon this observation, as to whether the diœcious character may not be a result of subsequent changes in the development of a once monœcious form, and suggests that all plants would be primarily monœcious but that there is a kind of exhaustion of the form—an old age of the race, as of the individual—when accordingly hermaphrodite fertilization becomes inefficient, and it becomes necessary that the sexual elements of distinct races should be combined to ensure the continuation of the species.

The Botany of the Malvern Hills.—Such spots as the Malvern Hills are peculiarly interesting to the botanist as well as to the geologist, and it is because they have special geological features that they present special botanical developments. The supposed igneous or metamorphic axis of the Malvern anticlinal carries with it a certain peculiarity of vegetation which is not met with in the immediately surrounding country, and, in addition to this, the height of the Hills has rendered them the refuge for Alpine forms when the Straits of Malvern flowed over the Severn valley. Mr. Edwin Lees, the Vice-President of the Malvern Field Club, has brought out the third edition of his little book on the flora of this district, which must be of great service to those who wish to explore the range and make the acquaintance of its botanical rarities. A sketch of the geology and physical geography of the range is also given, which appears to be considered—and very rightly—a necessary accompaniment of a local flora in these days. It is not only, however, by giving the two sets of facts, the botanical and geological, that the students of local floras should set forth the important connection of the two studies, but by tracing out in detail and completely the history of a flora as influenced by geological changes and the nature of the soil. To do this well requires great study and much extended observation. Mr. Lees unfortunately uses the Linnæan system, which really diminishes the value of his book. A special feature of interest in the volume is the recognition of the cryptogamic species, which often are passed over in silence in handbooks and pocket floras. Mr. Lees is a well-known student of these forms, and his account of them may be considered the most valuable part of his 'Botany of the Malvern Hills.'

The Malvales.—Dr. Maxwell Masters having carefully examined the relations of the families Malvaceæ, Sterculiaceæ, and Tiliaceæ of Bentham's and Hooker's Cohors VI., has arrived at the conclusion that though it may be desirable for convenience sake to separate the two former from each other, yet they are so closely related morphologically, that it is not possible to understand the peculiar structural relations of the one without comparing them with the corresponding parts of the others. Dr. Masters considers the stamens as organs of the highest importance in classification. "Not only," he says, "does the connection of the stamens furnish one of the best characters of the entire group, but even in the discrimination of the smaller sub-divisions (genera) the appearances presented by the column are of the greatest value."

Oblique Leaves.—In a late volume of the Boston Society of Natural History, Dr. Wilder shows that in the Elm the larger portion is in the upper or most elevated side; the leaves not lying with their edges horizontally. In the Hornbeam the outer or lower portion is the largest. De Candolle and Herbert Spencer have both tried to account for obliquity in leaves, but Dr. Wilder considers their reasoning to be insufficient. Dr. W. believes it to be caused by no external agency, but by an inherent constitutional force. The German botanists, especially Schimper and Braun, have long since investigated the development of leaves in connection with the general subject of phyllotaxis. They found that each leaf was primarily a swelling or wave of growth freeing itself from the axis of the embryo; and that differences in size between the sides of a leaf were caused by the greater force of the wave in its upward or downward movement. Such peculiarities as have been pointed out between the leaves of the Elm and the Hop Hornbeam exist therefore in the earliest formation of the leaf, while yet connected with the axis by a broad base, and before any constriction for the petiole has taken place. Professor Agassiz considers the word "antistrophe" as better expressing the inverse relation of corresponding parts on the opposite sides of a line than "symmetry." Dr. Wilder has shown that the corresponding leaves on each side of a shoot are symmetrical.

The Rubi, of Plymouth.—The Rev. A. Bloxham names a new Rubus after Mr. Briggs, who has recently given a very interesting account of the stations of the Rubi in his own neighbourhood. The marvellously protean genus *Rubus* is one of the most interesting studies at the present time for English botanists. By careful examination we may hope to see definite relations of cause and effect pointed out between the various species and their stations.

The Culture of Opium.—Mr. Heffler, of Smyrna, describes some of the difficulties and risks attending the cultivation of the poppy in Asia Minor. The agricultural implements used are most primitive, and no irrigation is applied. The poppy must be grown in a moist but not a too wet soil, and hence is very much subject to injury from variations of season. Accordingly it is sown at three different periods of the season, so that if one crop should fail, another may have a chance of success. This method also enables the labourers to gather first one field and then another, which is desirable from the scarcity of hands and the necessity of gathering just at the right time in the plant's development. When the seed capsule is considered to have arrived at maturity, the gatherers go into the fields and in a very skilful manner make horizontal and vertical incisions in the outer portion of the capsule, being very careful not to penetrate to the seeds. On the morning following this operation, the cuts are found to be covered with milky juice which has oozed from them, and which the gatherer scrapes off with his knife and wipes on a leaf. When he has accumulated a sufficient quantity on a leaf to make a ball, it is rolled up and left to dry in the sun. The period between the making of the incisions and gathering the juice is a very critical one, for should a shower of rain come on, as it often does at this season, the juice is entirely lost. The opium-growers are generally small landowners, who superintend the cultivation themselves with their families. The cakes are bought by travelling merchants, who convey them in sealed bags to Smyrna, and some few to Constantinople, where the bags are opened after being sold to the city merchants. Then they are carefully examined for adulteration and as to quality, three qualities being distinguished. It requires the greatest skill and long experience to become a good judge of opium cakes—odour, weight, texture, &c., being all important.

Akazga.—Akazga is a poison known from the reports of travellers, used as an ordeal on the west coast of Africa, and found by two French chemists to exert physiological effects similar to those of nux-vomica. A supposed sorcerer is made to drink an infusion of Akazga bark and then to walk over small Akazga sticks. If guilty, he stumbles and tries to pass the sticks as though they were great logs, eventually falling in convulsions and being clubbed by the surrounding savages. If innocent, the kidneys are said to act freely, and the poison is supposed to be thus eliminated. Dr. Fraser, of Edinburgh, has received specimens of Akazga in bundles of long, slender, and crooked stems, and examined its botanical relations and chemical properties. Consulting with Professor Oliver, of Kew, Professor Balfour, of Edinburgh, and Professor Dickson, of Glasgow, he comes to the conclusion that the Akazga plant is new to the flora of West Africa, and he supposes it may be a new species of Strychnos. He has succeeded in separating from it a crystalline alkaloid, closely resembling Strychnia, but differing from it in being precipitated by alkaline bicarbonates. Dr. Fraser made a careful comparison of the microscopic structure of the stems of Akazga and Strychnos nux-vomica, and was thus able to separate them still more closely. Amongst the parcels of Akazga which he examined, were certain twigs which had a different stem-structure, and failed to yield the chemical products of the other specimens. Is it not possible that those who escape in the ordeal may have been fortunate enough to get an infusion prepared from this "false Akazga" by mistake? Dr. Fraser terms the new alkaloid *Akazgia.*

The Uses of Pine Leaves.—In a paper lately read before the Society of Arts, Mr. P. L. Simmonds states that a new and curious application of a waste product is the utilization of the acicular leaflets of pine trees. Near Breslau, in Silesia, are two establishments, one a factory where the pine leaves are converted into what is called "forest wool," or wadding, the other, an establishment for invalids, where the waters used in the manufacture of this pine wool are employed as curative agents. The manufacture has extended, for there are now factories at Runda, in the Thüringer-Wald; at Yonkoping, in Sweden; Wagenerger, in Holland; in parts of France, and other places. Two cases of these products were shown at the last Paris and Havre exhibitions, which contained various illustrations, in the shape of wool for stuffing mattresses and other articles of furniture, instead of horse-hair; vegetable wadding, and hygienic flannel for medical application; essential oil for rheumatism and skin diseases; cloth made from the fibre; articles of dress, such as inner vests, drawers, hose, shirts, coverlets, chest preservers, &c., and other useful applications. In the preparation of the textile material an ethereal oil is produced, which is employed as a curative agent for burning, and as a useful solvent. The liquid remaining from the decoction of the leaves is used for medical baths. The membranous substance and refuse are compressed into blocks and used as fuel; from the resinous matter they contain, sufficient gas is produced for illluminating the factory in which the manufacture is carried on.

The Structure of the Diatomaceous Frustule.—Dr. John Denis Macdonald, F.R.S., of the Royal Navy, has published a very elaborate paper on the composition of the Diatom's shell, and the part it plays in the process of division. He finds the views expressed in the writings of Dr. Wallich (particularly in his paper on Triceratium, and on the diatom-valve, in the 'Quarterly Journal of Microscopical Science') most in accordance with his own independent researches. Dr. Wallich appears to have been the first to set forth clearly that the middle piece, or "zone," running round between the two large valves of the diatom, consists, while the frustule is intact, of two distinct plates, the one received within the other; and that the growth of such plates can only take place at the free margins, or those which are not connected with the valves. Dr. Macdonald shows that by the process of division (valve being formed within valve), the resulting diatom will ultimately become reduced to a very small size; and he observes that the species would be indefinitely diminished were it not for the process of conjugation, in which Mr. Thwaites showed that the produced sporangial frustule was very much larger than the parent cells. This diminution of size is very well illustrated in a diagram representing the progeny of the two valves of a divided *Biddulphia*, and by it the ultimate relations of the dividing frustules are exhibited.

Reproductive Organs of Lichens.—MM. A. Famitzin and J. Boranetsky have been recently investigating this matter, and are led to conclude that—

1. Not only algæ and fungi, but lichens also, are provided with zoospores.

2. Zoospores have been discovered in three very different genera of lichens, viz. *Physcia*, *Cladonia*, and *Evernia*; and as these genera were selected undesignedly, it is probable that zoospores exist in all other lichens furnished with chlorophyll.

3. The identity of free gonidia with unicellular algæ (Cystococcus of Nägeli) may be considered as demonstrated; consequently this is not a distinct genus, but only a phase of development of a lichen.

4. The culture of the freed gonidia of *Physcia*, *Cladonia*, and *Evernia* led us to expect that other lichens would afford forms corresponding with rudimentary algæ. Our researches prove this to be well founded. Vertical sections of the thalli of *Peltigera* and *Collema*, cultivated on moist earth, showed the filaments in disintegration, the augmentation in size of the gonidia, and their transformation into glomerules composed of spherical cellules. The gonimic cellules of *Peltigera* and *Collema* continued to live when separated from the thallus; those of *Peltigera* were identical with an alga called *Polycoccus*; those of *Collema* produced organisms similar to *Nostoc*. Consequently these three genera of algæ, hitherto regarded as distinct, are in reality only the gonidia of lichens in a state of development when separated from the thalli which produced them.

New Lichens.—The Rev. J. Crombie describes in the 'Journal of Botany' a number of new lichens from the well-searched neighbourhoods of the New Forest and Scotch moors. What he has been able to do is an encouragement to others to pursue the very fascinating study of these little plants; taking the student over mountain rocks, among old ruined towers, or under vast and aged tree stems—with a geological hammer and a strong knife in his hand, and no need of great tin-boxes and blotting-paper.

Deaths.—Carl von Martius, the great botanist and traveller, died at Munich, in December last, aged 74. Adalbert Schnitzlein, Professor of Botany at Erlangen, died in October, from the result of an accident whilst botanizing in the Tyrol.

The late Professor Harvey.—Those who would like to read the history of a good, well-loved, and great botanist should see the recently-published memoir of the late Professor of Botany in Trinity College, Dublin.

The Chair of Botany at Trinity College, Dublin.—We are glad to find that the fears of Dr. Wright's friends as to the election to the late vacancy in Dublin have not been fulfilled. Trinity College has not followed the nomination of the Science and Art Department, and Professor Wyville Thomson, though appointed lecturer in the Government College of Science, has not obtained the University chair, to which Dr. Edward Perceval Wright has been elected.

5. CHEMISTRY.

Without exception, the most important contribution to chemical science which has been published for some time is the paper recently read by Professor Graham, the Master of the Mint, on Hydrogenium. The author discovered some time ago that the metal palladium was capable of absorbing, or *occluding*, as he terms it, 800 or 900 times its volume of hydrogen; and the idea has forced itself upon his mind, that palladium with its occluded hydrogen was simply an alloy of a volatile metal hydrogen, in which the volatility of the one element is restrained by its union with the other, and which owes its metallic aspect equally to both constituents. How far such a view is borne out by the properties of the compound substance in question, will appear by the following examination of the properties of what, assuming its metallic character, may be named hydrogenium:—

The density of palladium when charged with 800 or 900 times its volume of hydrogen gas is perceptibly lowered, being reduced from 12·3 to 11·79; and ultimately, as the mean of several concordant experiments, the density of hydrogenium was found to be 1·951, or nearly 2.

The tenacity of the hydrogen-charged wire was found to be 81·29, that of the original palladium wire being 100. It is seen, therefore, that the tenacity of the palladium is reduced by the addition of hydrogen, but not to any great extent. It is a question whether the degree of tenacity that still remains is reconcilable with any view other than that the second element present possesses of itself a degree of tenacity such as is only found in metals.

The electric conductivity was tested by submitting a palladium wire before and after charging with hydrogen to trial, in comparison with a wire of german silver of equal diameter and length, at 10·5°. The conducting power of the several wires was found as follows, being referred to pure copper as 100:—

Palladium	8·10
Palladium + hydrogen	5·99

A reduced conducting power is generally observed in alloys, and the charged palladium wire falls 25 per cent. But the conducting power remains still considerable, and the result may be construed to favour the metallic character of the second constituent of the wire. As regards magnetism it was found that the addition of hydrogen to palladium added manifestly to the small natural magnetism of palladium. It follows, therefore, that hydrogenium is magnetic, a property which is confined to metals and their compounds. This magnetism is not perceptible in hydrogen gas, which was placed both by Faraday and by M. E. Becquerel at the bottom of the list of diamagnetic substances. This gas is allowed to be upon the turning point between the paramagnetic and diamagnetic classes. But magnetism is so liable to extinction under the influence of heat, that the magnetism of a metal may very possibly disappear entirely when it is fused or vaporized, as appears with hydrogen in the form of gas. As palladium stands high in the series of the paramagnetic metals, hydrogenium must be allowed to rise out of that class, and to take place in the strictly magnetic group, with iron, nickel, cobalt, chromium, and manganese.

The chemical properties of hydrogenium distinguish it from ordinary hydrogen. The palladium alloy precipitates mercury and calomel from a solution of the chloride of mercury without any disengagement of hydrogen; that is, hydrogenium decomposes chloride of mercury, while hydrogen does not. Hydrogen (associated with palladium) unites with chlorine and iodine in the dark, reduces a persalt of iron to the state of protosalt, converts red prussiate of potash into yellow prussiate, and has considerable deoxidizing powers. It appears to be the active form of hydrogen, as ozone is of oxygen. A wire charged with hydrogen, if rubbed with the powder of magnesia (to make the flame luminous), burns like a waxed thread when ignited in the flame of a lamp.

The general conclusions which appear to flow from this inquiry are—that in palladium fully charged with hydrogen, there exists a compound of palladium and hydrogen in a proportion which may approach to equal equivalents; that both substances are solid, metallic, and of a white aspect; that the alloy contains about 20 volumes of palladium united with 1 volume of hydrogenium; and that the density of the latter is about 2, a little higher than magnesium, to which hydrogenium may be supposed to bear some analogy; that hydrogenium has a certain amount of tenacity, and possesses the electricial conductivity of a metal; and finally, that hydrogenium takes its place among magnetic metals. The latter fact may have its bearing upon the appearance of hydrogenium in meteoric iron, in association with certain other magnetic elements.

A paper on meteoric iron has been communicated by M. Stanislaus Meunier to the 'Chemical News.' The numerous researches hitherto made with regard to the composition of meteoric irons have demonstrated in these extra-terrestrial bodies the existence of the following compounds:—

1. The general mass which is formed by the union of several alloys in which iron and nickel are predominant, and which we will designate under the name of nickeliferous iron. Among the substances comprised in this mass, the *Ramacite*, the *Iœnite*, and the *Plessite* will be specially mentioned.

2. The carburetted iron, comprising the *Campbellite* and the

Chalypite, recognizable by the carboniferous deposit which they give under the action of acids.

3. The sulphuretted iron, or *Tröilite*, which appears in nodules and in veins.

4. The phosphide of iron and nickel or *Schreibersite*. 5. *Graphite*. 6. The external crust. 7. The stony particles or crystals. 8. The gases retained by occlusion. 9. Several compounds which are only met with exceptionally, as *Chromite*, &c. Space will not allow us to give in detail the very ingenious methods adopted by the author for separating these different substances. It must be sufficient to say that he has succeeded in isolating each of these components in a state of purity and ascertaining their composition, with the exception of the gases, owing to his having employed for their separation a method which Professor Graham has since shown to be inapplicable.

Professor Stas, to whose researches chemists are so much indebted, has published a modification of Gay Lussac's method of estimating silver in the wet way. In the ordinary process a standard solution of salt is employed, but, as the precipitated chloride of silver is soluble in a solution of salt, it is impossible to carry out this principle to the minute accuracy which is sometimes required. M. Stas has now discovered that by substituting a bromide for a chloride in precipitating silver, this error may be absolutely removed.

An Italian chemist, Massino Levy, has devised a method of preparing nitrogen gas, which may be useful in some cases. It consists in heating bichromate of ammonia in a retort; the salt is transformed into green sesquioxide of chromium, and disengages vapour of water and nitrogen gas. In the ordinary process of bleaching wood-pulp it is very difficult to avoid a yellow or reddish tint, and if iron is present the paste generally blackens in a very short time.

M. Orioli has discovered a process of bleaching in which these objectionable results are obviated. To 100 kilogrammes of wood-pulp, 800 grammes of oxalic acid are added; this serves the double purpose of bleaching the colouring matter already oxidized, and of neutralizing alkaline principles. Two kilogrammes of sulphate of alumina, free from iron, are now added. This does not bleach of itself, but it forms with the colouring matter of the wood a nearly colourless lake, which enables the brilliancy of the product to be heightened.

At one of the recent meetings of the Manchester Literary and Philosophical Society, Mr. Sidebotham drew attention to the large number of galls, which appeared to be much commoner now than they were a few years ago. They were produced by the gall fly, *Synips Lignicola*; and, from experiments which he had tried, it appeared that the English galls were about two-thirds the value of the foreign ones, or, according to the present market value, they were worth about 66*s*. a cwt. The galls, even when in great numbers, do not appear to injure the trees. The proper time to collect them would be the middle of September, when the flies have all eaten their way out and laid their eggs for another year's supply. In the plantations where these galls abound, a man might collect easily half a cwt. in a day.

A not uncommon adulteration of glycerin is to mix sugar and dextrin with it. These substances have not hitherto been easy to discover when mixed with the glycerin; the following process is, however, said to answer perfectly:—To 5 drops of the glycerin to be tested, add 100 to 120 drops of water, 3 to 4 centigrammes of ammonium molybdate, 1 drop of pure nitric acid (25 per cent.), and boil for about a minute and a half. If any sugar or dextrin is present, the mixture assumes a deep-blue colour.

The abominable odour of bisulphide of carbon is a great bar to its employment in the arts. This, according to M. Millon, can soon be got rid of. The sulphide of carbon is first washed several times with distilled water, as in the purification of ether, and then transferred to a retort of large capacity containing quick-lime. After twenty-four hours contact the sulphide is distilled off from the lime, and received in a flask partially filled with copper turnings, previously roasted to remove all traces of fatty matter, and afterwards reduced by hydrogen. The lime remaining in the retort is strongly coloured. All the disagreeable odour of ordinary bisulphide of carbon is removed by this treatment, and when the nose is placed close to the mouth of the receiver, an ethereal odour is only perceived. With bisulphide of carbon thus purified, MM. Millon and Commaille have separated the perfume of milk to the extent of recognizing certain plants eaten by the cow—the *Smyrnium olusatrum* among others.

Professor A. Silvestri, of the University of Catana, has recently discovered a great quantity of citric acid in the fruit of the *Cyphomandra betacea*, a plant belonging to the family of *Solanaceæ* which is found here and there in the gardens of Sicily. It is indigenous to Mexico, and has spread itself into Peru and other parts of South America, where it is called *Tomate de la paz.* It is a woody plant, and attains to the height of 4 mètres. On analysis the fruit gives from 1 to 1·5 per cent. of pure citric acid. This acid, which probably exists also in our edible tomato, has already been discovered by Bertagnini in the potato, and will doubtless be found in all plants belonging to this tribe.

A plan of testing the strength of acetic acid, likely to be of great use to photographers and others, has been published in the 'Photographic Journal.' It was observed, we believe, independently by M. Berthelot and Mr. E. Chambers Nicholson, that an acid which, although of a high degree of purity, is not glacial, becomes inflammable when the temperature is raised to the boiling-point. If we take, for instance, about a drachm of the acid of 95 per cent., and heat it in a test-tube to the boiling-point, it will be found that the vapour takes fire on applying a lighted match, and burns steadily as long as the ebullition is maintained; if, however, 10 per cent. of water be mixed with the sample, there will be great difficulty in causing inflammation, and the vapour, when ignited, will only burn with a lambent flame of pale-blue separated cones, whilst below this strength the acid vapour is altogether uninflammable. By this test then (avoiding a too prolonged ebullition, which increases the strength of a weak acid), we have a ready means of estimating the quality of liquid samples of a high degree of concentration, without resorting to the more tedious method of acidimetry. It has only to be stated, in conclusion, that the boiling-point of the ordinary qualities of acetic acid, although higher, is so little removed from that of water, that the indications of the thermometer are not much more to be relied upon than those of the hydrometer. In many respects carbolic acid imitates the deportment of acetic acid in the characters above described; it likewise becomes glacial upon separation of the last traces of water.

M. Chabrier has studied at nitrification works, in particular circumstances, the different degrees of oxidation of the nitrogen, and especially nitrous acid. He has devoted attention to the estimation of this acid in saline mixtures, where nitrites and nitrates occur together with reducing agents, and has submitted to the Academy the result of the first part of his researches. The facts contained in this memoir are deduced from the following conclusions:—1st, in liquids containing at the same time nitrites, nitrates, and organic matter, the nitrous acid of the nitrites may be determined by the decolourizing action which hyposulphite of soda exerts on the iodide of potassium in presence of starch, and dilute sulphuric acid; 2nd, in the absence of nitrates and organic matter, the determination could be more easily made by the decolourizing of indigo solution, operating with the aid of heat, but out of contact with the air.

A combination of iodic acid with oxide of ethyl has been prepared by M. K. Lisensko. He finds that a mixture of equal volumes of ethyl iodide, and dry ether, readily acts upon argentic iodate. If the temperature is not allowed to rise above 10° C., the liquid remains colourless, and the new ether undecomposed. The solution distils between 37° and 40°. The distillate at first floats upon the water with which it had been mixed, but on passing a current of air through the liquid, in order to drive off ethyl ether, it sinks to the bottom of the vessel. All attempts at further purification failed; the liquid boils at 75° under decomposition. Organic chlorides are converted into iodides by the action of concentrated iodhydric acid. M. A. Lieben finds that this method of conversion seems to be a general one, and subject to limitation only in so far as some iodides at the moment of their formation are converted into hydride. Ethyl chloride, at 130° C., is almost completely converted into iodide, without evolution of gas or formation of any bye-product. The same is the case with butyl and amyl chloride.

Lipowitz has recommended the use of hypochlorite of lime (bleaching powder) as a means of detecting the adulteration of olive oil, and also of sweet almond oil, with the oil of poppy-seed. When eight parts of either olive oil or oil of sweet almonds is rubbed up and shaken with one part of bleaching powder, and left at rest, it will be seen that even after some four or five hours a layer of clean and limpid oil separates and floats at the top and surface of the mixture, which layer is, if the oils operated upon are pure, at least half the bulk of the original mixture; if, however, poppy-seed oil is mixed with either of the two oils just mentioned, and the same experiment then repeated, the mixture takes the appearance of a liniment, from which no oil separates. Sweet oil of almonds adulterated with one-eighth part of poppy-seed oil behaves as if it were almost pure poppy-seed oil. Büchner and Brande have found Lipowitz's statement correct as regards sweet oil of almonds, but not as regards oil of olives; but they add that the olive oil they operated upon was already old. The action of Lipowitz's reagent is explained by the fact of the rapid oxidation of all so-called drying oils, which on drying yield solid products before entirely changing, by continuously absorbing oxygen into water and carbonic acid. Linseed oil, hemp-seed oil, poppy-seed oil, oil from walnuts, croton oil, castor oil, are all drying oils. The drying of drying oils is, in fact, a process of slow oxidation of these oils.

Professor Parkes, F.R.S., of Netley, calls attention to the fact that it has always been seen that the action or non-action of water on lead could not be entirely accounted for by the usual statements on the subject; and lately Dr. Frankland has made a curious observation, which may throw light on the subject. He found that water which acted on lead lost this power after passing through a filter of animal charcoal. He discovered this to be owing to a minute quantity of phosphate of lime passing into the water from the charcoal. On comparing two natural waters, that of the river Kent, which acts violently on lead, and that of the river Vyrnwy, which, though very soft, has no action on lead, he found that the latter water contained an appreciable amount of phosphate of lime, while none could be detected in the Kent water. This observation may probably explain much of the discrepancy of evidence in respect of the action of soft water on lead.

Professor Tomlinson has advanced a very good explanation of a circumstance which has often been a stumbling-block for students:—Why does hydrochloric acid fume when let out into the air, while ammonia, which has a much stronger attraction for water, does not? After making several observations of specific gravity, boiling-points, &c., Professor Tomlinson comes to the conclusion that, although ammoniacal gas and hydrochloric acid gas are greedily absorbed by water, there must be some important differences in the constitution of the respective solutions. The alkaline solution is much lighter than its own bulk of water, whilst the acid solution is much heavier; also the presence of ammoniacal gas in water lowers its boiling-point, while the presence of hydrochloric acid in water has a contrary effect. Hence the mode of combination between ammonia and water must be different from that between hydrochloric acid and water. The one must be a case of simple adhesion, the other of true chemical combination as well as adhesion. Ammonia let out into moist air simply adheres to the moisture, and increases its volume. Vapour of alcohol, ether, &c., does the same. Now any amount of aqueous vapour that the air can maintain in an invisible, elastic state, at a given temperature, it can maintain with increased effect in the case of ammonia vapour, alcohol vapour, &c. Hence the combination of these vapours with the moisture of the air is necessarily an invisible compound. Hydrochloric acid gas, on the other hand, let out into the air, combines chemically with the moisture, producing condensation or diminution of bulk. Hence the compound is visible, just as the condensation of pure steam in air produces visible vapours. Fuming nitric acid and Nordhausen sulphuric acid are also cases in point. Concentrated nitric acid, exposed to the air, absorbs moisture until it attains the density of 1·424, when it distils unaltered at a boiling-point of 250°.

Dr. Carter Moffat has succeeded in fixing on paper the beautiful figures which are produced when oils, &c., are allowed to fall drop by drop on a surface of pure water, and which Professor Tomlinson has shown to be characteristic of each oil. The method is very simple; and is, briefly, to obtain a pattern on water, note the time, lay on the paper, glazed side downwards, for an instant, take out, draw through a plate of ink, remove, and wash with water. The process is capable of great extension, and will be valuable to paper-stainers and others. Several books of *oleographs*, as these figures are called, have been presented by Dr. Moffat to different individuals interested in them, and have elicited cordial approbation.

According to M. Oser, every time that solutions of sugar ferment under the influence of yeast, besides alcohol, a new alkaloid is produced. The chlorhydrate of this base crystallizes in hygroscopic tables, which become brown on exposure to the air. It appears that all fermented liquors contain the new alkaloid, or at least one of its compounds. The presence of such a substance in wine and in beer, till now entirely unknown, will doubtless explain certain effects of fermented liquors on the animal economy—effects which cannot be attributable to alcohol alone.

PROCEEDINGS OF THE CHEMICAL SOCIETY.

The first meeting of the season took place on Thursday, Nov. 5, 1868, Dr. W. A. Miller, V.P.R.S., &c., Vice-President, in the chair.

The first paper read was by Mr. W. H. Perkin, "On the Hydride of Butyro-Salicyl and Butyric-Coumaric Acid." The author's previous communications had shown that hydride of aceto-salicyl is an intermediate stage in the formation of coumarin from acetic anhydride and hydride of sodium-salicyl. By the substitution of other anhydrides for the acetic, he had obtained homologues of coumarin, and he now describes the hydride of butyro-salicyl, which forms the intermediate stage in the synthesis of butyric coumarin, as hydride of aceto-salicyl does in that of ordinary coumarin. It is an oil boiling at 260°–270° C. Hydrate of potassium decomposes it into hydride of potassium-salicyl and butyrate of potassium, and it yields with acetic anhydride a compound perfectly parallel with those produced by the action of the anhydride on the hydrides of ethyl-salicyl, aceto-salicyl, &c. When boiled with butyric anhydride and butyrate of sodium it yields butyric coumarin. By the action of hydrate of potassium, butyric coumarin yields butyric-coumaric acid, a true homologue of ordinary coumaric acid, and, like it, capable of yielding only monometallic derivatives.

The next was one "On the Application of Chlorine Gas to the Toughening and Refining of Gold," by F. B. Miller, F.C.S., Assayer in the Sydney branch of the Royal Mint. The methods now in use for effecting the above purposes are all more or less unsatisfactory, and the author has therefore devised a process which appears to satisfy all the requirements of the case in a single operation. A French clay crucible is saturated with borax. The gold is then melted in this crucible with a little borax, and a stream of chlorine gas is allowed to pass through it by means of a tobacco-pipe stem. In a few hours the whole of the silver is converted into chloride, which floats on the gold. The borax prevents the absorption of the chloride by the crucible, and also its volatilization, except in very minute quantities. As soon as the gold has become solid, the still liquid chloride of silver is poured off, and the gold is now found to have a fineness of say 993 parts in 1000. The apparent loss of gold is very little greater than is found in ordinary gold melting—being 2·9 parts in 10,000—whereas in the ordinary process it is 2. The Chairman, in proposing a vote of thanks to the author, remarked upon the great importance of the new process. Much of the gold imported into this country contained 60 or 70 ounces of silver in 1000, which could not at the present time be profitably extracted. The new method would probably be soon adopted by English assayers.

This was followed by a "Note on the Specific Gravity and Boiling-point of Chromyl Dichloride," by T. E. Thorpe, Dalton Scholar in the Laboratory of Owen's College, Manchester. The author prepared the liquid by distilling an intimate mixture of ten parts sodium chloride and twelve parts potassium dichromate with thirty parts strong sulphuric acid. He removed the free chlorine by repeated distillation in an atmosphere of carbonic acid. The specific gravity of the liquid so obtained was, at a temperature of 25° C., 1·92. The boiling-point, at a pressure of 733 millimètres, was found to be 116°·8. The dichloride cannot, however, be distilled without some slight decomposition.

The same author, Mr. T. E. Thorpe, then gave a paper "On the Analysis of the Ashes of a Diseased Orange Tree (*Citrus aurantium*)." The orange plantations along the south-eastern coast of Spain and in the adjacent Balearic Isles have recently been visited with a severe epidemic, the rapid progress of which was naturally viewed with no little anxiety by the people, since the culture and exportation of oranges constitute one of their principal industries. The origin of the disease is involved in complete obscurity, and as yet it has baffled all attempts at remedial measures. The first symptoms are observed in the leaves, which turn yellow and drop off; a most disgusting odour exhales from the roots, and in a few days the tree succumbs. The violence of the disease is now, happily, much abated, and it appears to be dying out. We have no space for the details of the analyses. Tables are given which show the percentage composition of the ash of the roots, stem, branches, and fruit, and the results are compared with the analyses of the ash of healthy plants made by Rowney and How, and by Dr. Richardson. The most remarkable differences observed in the comparison are given in the following table, showing the percentages of lime and phosphoric acid:—

	Lime.	Phosphoric Acid.
Root of diseased plant	61·82 ..	1·57
Stem of ditto	70·67 ..	2·66
Root of healthy plant	49·89 ..	13·47
Stem of ditto	55·13 ..	17·09

The phosphoric acid is thus shown to be in deficiency in the diseased plant, and the lime in excess. Similar differences cannot, however, be traced in the ash of the fruit.

At the meeting on November 19, 1868, Dr. Warren De la Rue, F.R.S., the President, in introducing the business of the meeting, observed that their object on the present occasion was to discuss certain proposed alterations in the bye-laws, by which a greater number of Fellows would be admitted to a share in the government of the Society. The Council had long felt anxious to effect this object; and finding that the Charter did not permit them to increase the number of the Council, they now proposed to raise the number of Vice-Presidents, who had not filled the chair, from four to six. This alteration would, it was felt, infuse some new blood into the governing body.

Formal alterations in the bye-laws, to provide for the proposed change, were then carried unanimously.

Mr. W. H. Perkin then made a communication "On the Action of Chloride of Lime on Aniline."—In this paper the author points out the difference between Runge's blue and aniline purple, and shows that the blue can be changed into the purple when decomposed by heat.

Professor Church gave an analysis of a meteorite from South Africa.

The meteor in question was seen by a native to fall at Daniel's Kuil, a place about two days' journey N.N.E. of Griqua Town. The native said it was warm, and smelt of sulphur, when he picked it up. He offered it to the Rev. James Good, a missionary in Griqua Town, who declined it, and recommended him to take it back to the place where he found it! Instead of doing so, he gave it to Captain Nicolas Waterboer, and from his hands it passed into those of Mr. J. R. Gregory, of Russell Street, Covent Garden, then at the Cape, and is now in the British Museum.

It was small in size, of an irregular oblong form, weighing 2 lbs. 5 oz. It was covered with a dark-grey crust, speckled here and there with reddish-brown spots, these spots arising from a partial oxidation of the ferruginous materials of the stone. Its density was rather low, namely, 3·657 and 3·678, as found in two determinations. The following was given as the analysis of the meteorite:—

Nickel-iron (containing 5·18 per cent. nickel), 29·72; Tröilite, 6·02; Schreibersite, 1·59; Silica and Silicates, chiefly olivine and labradorite, 61·53. Carbon, oxygen, other constituents, and loss, 1·14.

A paper on the "Action of Salt on Chessylite" then followed by the same author.

At the meeting of the Chemical Society, on December 3rd, the President announced that the Council had that evening adopted a resolution which would, it was believed, tend to promote scientific investigation. At the present time gentlemen were frequently deterred from the prosecution of interesting investigations by the great expense which they entailed upon the experimenter. To mitigate this difficulty it was now resolved that a certain sum of money not exceeding 50*l.* should be set aside annually as a grant fund in aid of original research. Any claims for grants from this fund which were sent in would be investigated by a committee consisting of four members of council. The Committee recommended that, except in special cases, each single grant should not exceed 10*l.* In accordance with this resolution, gentlemen who wished to prosecute researches were now invited to apply in writing to the Secretary for grants. It was of course to be understood that results obtained with the assistance of such grants must be communicated in the first instance to the Chemical Society.

Two papers followed of great theoretical interest, but too abstruse to bear condensation here. They were "Researches on the Action of Sodium on the Ethers of the Fatty Acids," by Professor Wanklyn, and on some compounds of "Phosphorus with Nitrogen," by Dr. J. H. Gladstone.

On December 17th the only paper was by Dr. J. Emerson Reynolds, "On the Isolation of the Missing Sulphur Urea." The new substance crystallizes in long fine needles or in short thick prisms, in either case belonging to the trimetric system. It is not deliquescent in moderately dry air, is very soluble in water and alcohol, and sparingly so in ether. The solution froths slightly on agitation, has a neutral reaction, and a somewhat bitter taste. Heated with water in a sealed tube for some hours to 140° C., it is reconverted into sulpho-cyanate of ammonium, as may be shown by the iron test. The urea does not give a colour-reaction with the test. Hydrochloric and sulphuric acids effect a similar change. The substance fuses at 156° C. Heated to a higher temperature in a closed tube it evolves sulphide of ammonium, carbonic disulphide and ammonia; the mixture blackens, a yellow oil distils over, and a white mass remains which strongly resembles Liebig's hydromellone. A beautifully-crystallized nitrate of the new urea was prepared by treating the strong aqueous solution with nitric acid of sp. gr. 1·25. No hydrochlorate nor oxalate could be obtained.

At the meeting on January 21st, the first paper read was, "On the Chemical Composition of Canaüba Wax," by Nevil Story Maskelyne, M.A. This wax is the product of a palm—the *Copernicia cerifera*—known to the Brazilians as the Canaüba tree. The glaucous coating which protects the younger leaves contains the wax in the proportion of about 50 grains to the leaf. It is collected and melted into a mass, and in this state constitutes a pale yellow or greenish body, somewhat harder and less resinous than the wax yielded by the noble palm of the Cordilleras. Its specific gravity is 0·99907, and its melting-point 84° C. The author found that the wax contained no less than one-third of its mass of free wax alcohol—a fact of no little interest in vegetable physiology.

A paper then followed on a subject of great importance to metallurgists, namely, "The Connection between the Mechanical Qualities of Malleable Iron and Steel, and the Amount of Phosphorus they Contain," by Dr. B. H. Paul. It is generally considered that very small quantities of phosphorus in malleable iron and steel are most prejudicial to the quality of the metal. Quite recently an eminent metallurgist had stated as a fact that much less than ·3 per cent. of phosphorus produces a decided and injurious effect on steel. The author had, however, been unable to discover any evidence sufficient to justify such a conclusion, and still less any reasonable explanation of it. He had recently had an opportunity of testing the truth of this conclusion, by determining the phosphorus in some samples of the iron and steel made by the new nitrate of soda process, from British pig-iron known to contain phosphorus. Seven bars of iron and two of steel, made by the Heaton process were examined; their tensile strength and extension had been determined by Mr. Kirkaldy. The iron bars had a tensile strength of from 46,547 to 52,842 lbs. per square inch of area, and an extension, when subjected to this strain, of from 21 to 28·6 per cent. of their length. The two cast-steel bars had tensile strengths of 80,916 and 106,602 lbs., and extended to 3·3 13·7 per cent. of their lengths. In the iron bars the author found ·144 to ·38 per cent of phosphorus (average ·237 per cent.), and in the two steel bars ·24 and ·241 per cent. The author therefore thinks himself justified in asserting that the commonly received opinion on this subject does not always represent the truth. An animated discussion followed the reading of this paper.

On February 4th the members assembled to hear a lecture by Dr. Wallace, on the "Chemistry of Sugar Refining." This was too long to allow of our condensing it into an intelligible abstract. The author commenced by drawing attention to the statistics of the sugar trade in this country, from which it appears that the total value of the imports of sugar during 1868 amounted to 21,000,000*l.* The various stages of selection of the raw sugar, solution, decolourizing the syrup, filtration through charcoal, revivifying the charcoal, and evaporation of the liquor were then fully described. The lecture, which was fully illustrated with tables and diagrams, was followed by an interesting discussion.

6. ENGINEERING—CIVIL AND MECHANICAL.

A GRADUAL change seems to be creeping over the minds of railway engineers, the result of which may not improbably be that some long-acknowledged principles will soon become obsolete. There can be no doubt that the best line of railway, and that which is most cheaply and economically worked, is the one with easiest gradients and longest curves, a perfectly level and straight line being of course the acme of perfection. It is, however, possible that such advantages as to working expenses may be too dearly purchased at the expense of capital, in consequence of the more numerous cuttings, viaducts, and tunnels that would be required, and the greater breadth of land that, in the case of cuttings and viaducts, would have to be purchased; attention is consequently now being directed to the possibility of constructing surface lines, the cost of which would be very small compared with that of our present systems of railways. The Mont Cenis Railway has clearly solved the problem as to the possibility of working up inclines of 1 in 12 and round curves of only two chains radius; and this, it may here be stated, is quite practicable without the aid of the central rail, the use of which is beginning to be seriously doubted. Trains have indeed been worked on the Baltimore and Ohio Railway up inclines of 1 in 10, where coupled engines drew after them a load equal to their own weight; on the Jeffersonville, Madison, and Indianapolis Railway there is an incline of 1 in 16½ of 1¼ mile in length; whilst in South Wales some of the mineral lines near Aberdare are regularly worked with locomotives on inclines of 1 in 18. The steeper the incline, the less is the adhesion of the locomotive wheels to the rails, and consequently it is capable of drawing only a lighter load: under similar circumstances also the resistance of a train is considerably increased; thus, on a gradient of about 1 in 150 its resistance is doubled as compared with working on a level, and trebled on a gradient of 1 in 70 or 75. With these data it is easy to calculate upon the probable economy of constructing steep gradient lines, having reference to their less original cost, although probably their working expenses would be increased. On the Metropolitan and St. John's Wood Railway, on its extension to Hampstead, the line will have an incline of 1 in 27 for ¾ mile; the Mauritius Railway in its ascent from Port Louis rises 1817 feet to the summit, a distance of 16 miles, in which an aggregate length of 13,526 feet consists of gradients of 1 in 27, and with engines weighing 48 tons, passenger trains of about 50 tons are carried up to the summit at the rate of 12 miles per hour, including stoppages. Mr. Brumlees' proposed Metropolitan and Brighton line would present no heavy works for construction, the gradients nowhere exceeding 1 in 60, and there being no curve of less than 30 chains radius. Whilst the possibility of working steep gradient lines is thus clearly proved, there can be no doubt with reference to their greater economy in construction; with our present advancement of knowledge, however, a gradient of 1 in 40 is probably the steepest that should be allowed when practicable, and coupled engines only should be employed, of as great weight as can be obtained, and having a good long wheel base.

Under the provisions of an Act of Parliament passed last session, all trains running distances of twenty miles and more, without stopping, must, after the present month (April), be supplied with some sufficient means of intercommunication between passengers and guards. With a view to test the different means for accomplishing this object, some experimental trips were undertaken on the line between York and Scarborough at the latter end of November last, and on the London, Chatham, and Dover Railway, between London and Sevenoaks, during the following week. Three systems have been proposed for the purpose, *viz.*—1. The rope pulls, which is the oldest of them all. 2. The electrical signalling system, of which there are many varieties, and some of them have already been in use for a length of time on the various lines of railways. And 3. The pneumatic system, which, whilst it is the newest, is also in many respects the most efficient. Space will not admit of our giving a detailed description of the several systems that were submitted to trial. The principle of the rope and electric bell systems will probably be well known to most of our readers, and we shall not therefore make further reference to them here. The pneumatic system, being novel, may, however, fairly claim a brief notice. The signalling apparatus consists of a heavy gong upon the engine or tender, and a smaller one in the guard's van. Both these gongs are struck by hammers, which receive direct motion from the train, when a signal is given. When no signal is passed from passengers or others, these hammers are kept away from the gongs, and they are put into gear in the following manner. A tube runs along the whole train, beginning at a pump in the tender, passing from carriage to carriage, and ending in a plug at the back of the train. This pipe, which is worked by the machine, keeps pumping the air out of the pump, and sustains in it a partial vacuum. Underneath those vehicles, which are supplied with gongs, there are shallow cylinders in connection with the vacuum-tube, from which the air being exhausted, their pistons are drawn backwards, and pull thereby the striking portions of the bells out of gear. Over each compartment a T-piece is inserted in the tube, and a plug is fitted into its lower stem so as to keep the tube air-tight. The passengers give signals by pulling out these plugs, and this, breaking the vacuum, causes the bells to fall into gear.

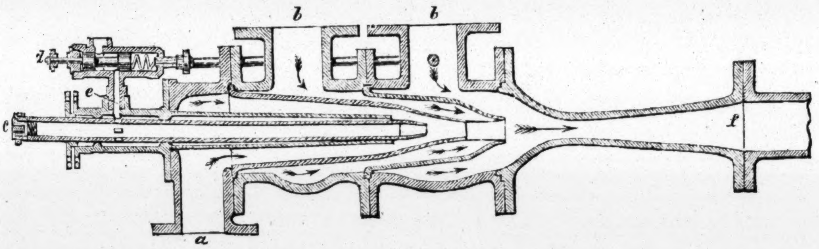
That the pneumatic principle possesses many advantages over the other two, both as to certainty of action and from its non-liability to be tampered with, is beyond a doubt: but the Committee of Railway Managers have nevertheless recommended the rope system, probably on account of its cheapness, and their recommendations have been accepted by the Board of Trade.

The anticipated difficulties attendant upon the location of the great floating-dock recently constructed in this country for Bermuda, in consequence of the insufficient depth of water at the selected site, has led to a proposal by Messrs. Gwynne & Company for the use of a hydraulic dredger for the purpose of increasing the depth of water where the dock is to be finally moored. The principle upon which this dredger is constructed is based upon the fact that sand or other loose earthy material can be freely passed through a centrifugal pump, when mixed with water, in the same manner as the water itself is passed through it. If the sand to be dredged can be well stirred up and the pump be placed under water and close to the sand itself, the rapid removal of the latter is certain; and Messrs. Gwynne's idea is therefore to get their pump to work down at the very bottom, to stir up the sand mechanically, and to conduct all that is so stirred up directly into the pump itself. It would then be driven up a wrought-iron pipe, to the bottom of which the pump is fixed, and delivered in a stream into a barge.

Few people could form any idea, at the first introduction of Giffard's Injector, which has now so generally taken the place of donkey-pumps for feeding boilers, what an important part the principle involved in its construction was likely to play in the economy of steam-engines generally; and even now one would be scarcely justified in assuming that the extent to which it is applicable has been fully realized. Testimony has been amply and repeatedly borne to the correctness of the principles of its construction, but the extent of its economical results is, perhaps, not so widely known as might be. Professor Henry Morton, in the course of a paper recently communicated to the Journal of the Franklin Institute, stated, "That the entire force which passes from the boiler in the issuing steam is returned to it, with the exception of that expended in lifting and injecting the feed-water, and so much as is lost by radiation of heat from the various parts and connections." M. Ch. Combes, Inspector-General and Director of the *Ecole des Mines*, says that the Injector is "without doubt the best of all those hitherto used for feeding boilers, and the best that can be employed, as it is also the most ingenious and simple," and he further adds, "it is theoretically perfect."

The applicability of the Injector to other than mere feed-water supply has not long been permitted to remain a matter of doubt; and besides other purposes to which it is now applied may be mentioned Messrs. Yarrow and Hedley's plan, by which it has been adapted for clearing out the bilge-water from vessels, for which duty it has been fitted into some steam launches lately built by that firm. It has also been applied as a steam syphon-pump, for supplying locomotives with water in places where a pump for that purpose is not available. In this case the steam is taken from the boiler of the locomotive to be supplied with water, which, passing through an injector, forces the water up through the stand-pipe.

The most valuable application of the principle as yet attained is, however, to be found in Morton's Ejector Condenser, which invention has recently been brought before the Scottish Institution of Engineers, by Professor W. J. Macquorn Rankine. This ingenious machine will be understood better by reference to the accompanying engraving, in which *a* represents the water-inlet; *b b*, the exhaust passages; *c*, the regulating spindle; *d*, the self-adjusting steam-valve; *e*, the steam inlet; and *f*, the discharge-pipe. It consists of three concentric tubes terminating in conoidal nozzles, and opening into the hot well or waste-water receptacle by a common and gradually-widening mouth-piece. The central tube is in communication with the water-tank from which the current of injection-water is obtained, while each of the other tubes conveys the exhaust steam from one of the cylinders. As the result of experiments made with one of these condensers, fitted to a pair of steam-engines of 24-horse power collectively, Professor Rankine estimated the saving of power through the dispensing with an air-pump equivalent to the doing away with a resistance of 0·6 lb. per square inch area of steam-pistons; and he found it to be on an average of several experiments just 1-horse power, being about 4 per cent. of the mean indicated horse-power of the engines.



Proceedings of Societies.

The number of Societies meeting in different parts of England and Scotland for the discussion of matters relating to engineering, renders it impossible to do more than briefly allude to some of the more important papers read before them during the period embraced in this review.

Institution of Civil Engineers.—A paper by Mr. John Frederick Bourne, "On the Roman Rock Lighthouse, Simon's Bay, Cape of Good Hope," is instructive, as pointing out the causes which led to the failure of the original structure. The building consists of a circular tower of cast-iron plates, but it had to be surrounded by a granite casing to a certain height, owing to many of the plates having cracked after its completion. The subject of "Lighthouse Apparatus and Lanterns" was dealt with in two papers by Mr. D. M. Henderson and Mr. J. T. Chance, M.A., in which all the best practice of manufacture at the present day was fully detailed. Of course the manufacture, grinding, and polishing of the glass for the apparatus formed the most important feature in these papers; but the various kinds of lamps were also explained, and, in conclusion, the means adopted for lighting the entrance to Odessa harbour were described. The importance of some improved means for coal-getting has led to the production of two papers by Mr. S. P. Bidder, jun., and Mr. C. J. Chubb, the object of both being a consideration of the means available for getting coal more economically and with greater safety to the miners. A paper "On the Mauritius Railway," by Mr. James R. Mosse, afforded some very valuable information with respect to the working of steep inclines, which subject has been more fully entered into at page 282 of these Chronicles.

Institution of Mechanical Engineers.—At a General Meeting of this Institution at Birmingham on the 5th November last, three papers were read on the following subjects; namely: "On the further Utilisation of the Waste Gas from Blast Furnaces," by Mr. Charles Cochrane, of Dudley; "On an improved Friction Coupling and Break, and its application to Hoists, Windlasses, and Shafting, &c.," by Mr. T. A. Weston, of Birmingham; and "On the Moulding of Toothed Wheels, and an improved Wheel Moulding Machine," by Mr. G. L. Scott, of Manchester. The author of the first-named paper stated that, with the increased capacity of the present large blast furnaces in the Cleveland district, the waste gas given off from the furnace is so far impoverished, both in quantity and quality, that, in order to obtain a uniform supply of gas for heating purposes at the steam-boilers and hot-blast stoves, it is of importance to utilize the whole of the gas given off from the furnace, by preventing the loss of gas hitherto occurring at the times of lowering the closing cone or bell for charging the materials at the top of the furnace; and this, Mr. Cochrane would accomplish by doubly closing the furnace top, the ordinary closing bell and hopper being completely closed in by the addition of an outer cover, containing flap doors, through which the charging materials are filled into the hopper.

Society of Engineers.—The most important papers brought before this Society during the present session have been one on "Modern Gasworks at Home and Abroad," by Mr. Henry Gore; and another "On the Application of Steam to the Cultivation of the Soil," by Mr. Baldwin Latham. Both of these papers contain matters of vast importance at the present time, especially the latter one; but the subjects dealt with are of such a character that it would be impossible to do them justice in the few lines which could be given to them here.

Institution of Engineers in Scotland.—Professor Sir William Thomson has recently introduced before this Institution a new Centrifugal Governor, the principle of which is to employ the increase of centrifugal force produced by increase of speed, by making it the normal pressure for a frictional arrangement directly and simply resisting the rotary motion. A simple modification of Sir W. Thomson's governor allows a plan invented by Professor Fleeming Jenkin to be applied, by which it would be converted into a powerful steam-governor.

LITERATURE.

There are so few works which entirely devote themselves to the subject of Irrigation, that every fresh one must be considered as an important addition to our Engineering literature. Few, if any, of note exist beyond what have resulted from the pens of officers of the Indian Government, and now we have to notice another work emanating from a similar source, entitled 'Irrigation in Southern Europe,'* by Lieutenant C. C. Scott Moncrieff, R.E. This volume was compiled by Lieutenant Scott Moncrieff after a visit to the principal Irrigation works in Southern France, Spain, and Italy, and it will be found to contain much valuable information regarding them which is not to be met with elsewhere. The account of the works in Italy is not so complete as of those in France and Spain, as the author has wisely abstained from going too minutely over the ground so admirably described by the late Captain Baird Smith in his work on 'Italian Irrigation.' In the book now before us, many of the most important headworks, sluices, &c., are illustrated by woodcuts, and the subject of the administration of waters in the different countries is fairly described. In an appendix there is given a translation of the celebrated Spanish Law of Waters, of 3rd August, 1866, under which concessions are granted for the construction of works of irrigation in Spain. A chapter on the Meadow Irrigation of the Mosel Valley is especially interesting, as it gives an account of a system of irrigation not previously described, so far as we are aware, in any work on a similar subject.

'The Railways of India,' † by Captain Edward Davidson,

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* E. & F. N. Spon: London, 1868.

† Ibid.

R.E., is another work which cannot fail to be acceptable at the present time, containing as it does an account of their rise, progress, and construction. It has been compiled from the records of the India Office, and is stamped with additional authority from the fact of its author having formerly been Deputy Consulting Engineer for Railways to the Government of Bengal.

7. GEOLOGY AND PALÆONTOLOGY.

(*Including the Proceedings of the Geological Society, and Notices of Recent Geological Works.*)

The Palæontographical Society have just issued their twenty-second annual volume, and, as usual, it is a bulky one; but, though large, it is good. It consists of a series of six parts, all continuations of Monographs now in progress.

(A.) In the first Dr. P. Martin Duncan introduces us to the corals from the White Chalk, the Upper Green-sand, and the Red Chalk of Hunstanton.

Twenty-eight species are illustrated in the nine plates which accompany this part, and many more are enumerated which Edwards and Haime figured and described in the Palæontographical volume (VIII.) for 1853. Such forms as *Trochosmilia*, presenting numerous minor differences of doubtful specific value, have been entered as *varieties* under a common species. This trinomial nomenclature proves exceedingly convenient where the amount of character to be expressed is trivial.

(B.) Mr. Henry Woodward contributes a second part to his Monograph of the fossil *Merostomata*, belonging to the genus *Pterygotus*. The specimens figured are all from the Upper Silurian of Lanarkshire, where they are collected by a Mr. Slimon, who ingeniously turns aside the stream of Logan Water in the summer season, and then excavates the beds which lie beneath. The fossils are preserved (often in a wonderfully perfect state, considering their extreme tenuity) upon the surface of olive-green and grey slates, frequently with all their appendages attached.

Mr. Woodward has pursued the same course as Dr. Duncan, and we find in this part figures and descriptions of four *varieties* of *Pterygotus bilobus*. Six plates are occupied with their illustration. These queer creatures, with their chelate antennæ, large heart-shaped lip-plates, great staring compound eyes, and long fish-like bodies, remind one strongly of larvæ of some aquatic insect. The largest of all the *Pterygoti* is *six feet* in length!

(C.) Again we welcome Mr. Davidson, with his splendid suite of

Silurian "Lamp-shells," or *Brachiopoda;* he is truly the gold-medallist of invertebrate palæontology. His Monographs are altogether *his.* He draws the wood-cuts, he draws those beautiful lithographs; everything is done withhis own hand. Here are fifteen quarto plates, *each of which,* to look at it, must have been a good ten days' work to draw, even after his great experience of the group. How he must love his task to stick by it so manfully year after year! There are more than eighty-eight species and varieties, many of which have a dozen figures in illustration of one species.

(D.) The worthy Professor Phillips adds Part IV. to the British Belemnites, which so many years ago he took under his care. The seven plates (which include three double-sized ones) were executed in Paris, from drawings sent out by Mr. Phillips. They exhibit well the beauty and clearness of French lithography. A great deal, however, depends on the printer. The Professor gives the positions and horizons of twenty species of Belemnites in the strata of the Yorkshire coast, from the Leda-beds to the Lower Lias shale, prepared from his own careful observation, as taught him by his uncle, William Smith, the father of English Geology, the man who was the first to show that strata could be identified by their fossils.

(E.) Professor Owen has added a third part to his Monograph on the Fossil Reptilia of the Kimmeridge Clay, belonging to the genus *Pliosaurus.* In Plates I., II., and III. he gives views of the under or palatal surface of the skull of *Pliosaurus grandis,* and of the upper surface of the lower jaw of the same animal, portion of premaxillary (natural size), jaw, and parts of crania of *Pliosaurus trochanterius,* from the Kimmeridge Clay, Dorsetshire; collected and presented to the British Museum by J. C. Mansel, Esq. The head of *P. grandis* must have been nearly six feet in length, and reminds one (especially the lower jaw) of the cachalot or sperm-whale. Lastly, the Professor figures a very perfect paddle of *Pliosaurus portlandicus,* from the Portland Oolite of the Isle of Portland; also in the British Museum.

(F.) Messrs. Boyd Dawkins and W. A. Sanford add Part III. to their British Pleistocene *Felidæ,* including *Felis spelæa,* Goldf., and *Felis lynx,* Linn. Two single and two double plates are occupied with figures of the limb-bones and pelvic-bones of *F. spelæa,* and one plate with the skull and lower jaw of the Lynx. Of this new cave mammal the authors observe, there is sufficient evidence to prove that the animal was specifically identical with the *Felis* (*lynx*) *borealis* of Norway, or with the variety *F.* (*lynx*) *cervarai* of Siberia. The discovery of the Lynx, a carnivore hitherto unknown in Britain, was made by Dr. Ransom in a fissure that penetrates the Permian Limestone in Pleasley Vale, Derbyshire, termed "The Yew-tree Cave."

The City of Manchester is determined to be to the fore. It is proposed to extend Owen's College into a University, under the title of "Manchester and Owen's College." A large sum (80,000*l.*) is already secured, and the buildings are planned. What will Government do? They have, by the mouth of one of their chief members, intimated that they could do nothing. We are desirous to record that Mr. W. Boyd Dawkins, M.A., F.R.S., of the Geological Survey, whose researches in Fossil Mammalia of the Quaternary Period are so well known, has been appointed to the chair of Natural History at Manchester. Mr. Dawkins, it will be remembered, was the first Burdett-Coutts' Scholar at Oxford.

The Museum of the City of Manchester undoubtedly possesses the finest collection of fossil botanical specimens ever brought together in illustration of the Flora of the Coal Period, by Edward W. Binney, Esq., F.R.S., F.G.S., who has devoted so many years of his life to this branch of geological inquiry.

The Geological Society of Glasgow have just recently issued Fasciculus I. of their quarto Transactions, Palæontological Series. It consists of a Monograph by Mr. Thomas Davidson, F.R.S., "On the Upper Silurian Brachiopoda of the Pentland Hills, and of Lesmahagow, in Lanarkshire;" and contains descriptions of twenty-six species belonging to thirteen genera of Upper Silurian Brachiopoda from the Pentland Hills, and a single species of *Lingula* (*L. minima*), and an uncertain species of *Rhynchonella*, from Lesmahagow. They are illustrated by the author, with his accustomed skill, in three very beautiful plates. This publication, which is started for the express purpose of illustrating Scottish fossils, deserves to be supported by all who take an interest in North British Palæontology.

Mr. A. Keith Johnson, F.R.G.S. of Edinburgh, has published a small quarto Physical Atlas (price 12*s.*), for the use of schools. From the glance we took of it, we were favourably impressed with its neat, clear, and attractive appearance. The maps are coloured to show regions of winds, currents, snow-lines, geological formations, geographical distribution of plants and animals; in fact, on a smaller scale, all that the larger folio Atlas teaches. One map is devoted to illustrations (drawn by A. Geikie, Esq., F.R.S., &c.) of geological features of land; sections of various formations illustrating faults, anticlinal and synclinal curves, glaciers, volcanoes, and all the other phenomena which are treated of in this branch of natural science.

Mr. Scrope, in a communication to the 'Geological Magazine,' vol. v., p. 537, "On the supposed Internal Fluidity of the Earth," observes, "I am gratified to find that the views I entertained and published, more than forty years ago, as to the nature and *modus operandi* of the subterranean agents of change in the earth's crust are now becoming recognized as true by many—perhaps the majority of geologists—more especially as respects the large part played in these movements by the water contained in the interior heated matter, which eventually, on its superficial cooling, forms the substance of all hypogene rocks. For entertaining this view, I was at that early period subjected to much ridicule, and my arguments generally disregarded."

No better proof can be given of the value now set on the work so long ago performed by this eminent geologist than the fact here referred to, and the writings of Lyell, Phillips, Forbes, and others, testify how much they have themselves learned from this great master.

Professor Owen has an article * on the gigantic Beaver of the Cromer Forest-bed (*Trogontherium Cuvieri*), in which he describes the femur, tibia, calcaneum, and dentition, maintaining its position and distinctive characters, as pointed out by him in 1845.

Mr. Woodward calls attention to the curvature of the tusks in the Mammoth from Ilford, and compares it with the specimens in the British Museum from Siberia and elsewhere, and shows clearly that all the tusks of *E. primigenius* have, in aged individuals, a tendency to curve inwards at their extremities.

Mr. Carruthers describes some new Coniferous fruits † from the Secondary rocks, also a new genus of Cycad from Scarborough.‡

Messrs. Meek and Worthen have published in their 'Palæontology of Illinois' a most interesting series of Articulate Fossils from the Coal-measures of Grundy County, Illinois. Commencing with two new species of *Phyllopoda*, *Ceratiocaris sinuatus*, and *Leaia tricarinata*, they proceed to describe a new and very remarkable form of *Eurypterus* (*E. Mazonensis*), very distinct from those described by Hall, from the State of New York: a new *Limulus* (*Euproops Danæ*), nearly related to *Prestwichia anthrax:* two new Isopods, *Acanthotelson Stimpsoni* and *A. Eveni*. A third form, *Palæocaris typus*, compared by Messrs. Meek and Worthen with *Gampsonyx fimbriatus*, from the Trias, is by them referred to the *Decapoda-Macrura ;* but its affinities appear to us far closer with the *Mysidæ* among the *Stomapoda*.

They have found good evidence of *Anthrapalæmon* (a short-tailed lobster), a species of which they name *A. gracilis*. Still more interesting is it to learn that many remains of *Insecta*, *Arachnida*, and *Myriapoda*, of the same age, have been met with. They are—1. *Euphoberia armigera*, a large species of centipede, upwards of 4 inches in length, and preserved in a very perfect state. Another genus of Myriapods (*Xylobius Sigillariæ*) has been described by Dr. Dawson, from the Coal-shales of the South Joggins, Nova Scotia,* and since by Mr. Woodward, from the Coal-fields of Huddersfield and Glasgow.†

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* 'Geol. Mag.,' vol. vi., p. 49.

† Ibid., 1869, January, p. 1, Plates I. and II.

‡ Ibid., 1869, March, p. 97, Plate IV.

A still larger form, named *Euphoberia major*, resembling the fossil from Coalbrook-dale, described by Mr. Salter as *Eurypterus* (*Arthropleura*) *ferox*,‡ has been discovered in the Iron-stone Coal-measure nodules of Grundy County, Illinois.

A very well-preserved Scorpion—named by them *Eoscorpius carbonarius*—is figured and described, which in structure closely resembles the *Scorpio Europæus*, now living, save that the dorsal plates of the thoracic segments appear to be narrower than in the living form. How vast is the measure of the life-time of this species of air-breather of the Coal-period, whose descendants, apparently unchanged in form or organs, are living now in America, Europe, Africa, and Asia, and even Australia, and the fossil remains of which have now been discovered in the Coal-measures of Bohemia and North America. A second form of Scorpion, but very unlike any recent genus—named *Mazonia Woodiana*—is also recorded. Whether it had a long and slender abdomen, like the ordinary *Scorpio*, or—like *Chelifer* and *Thelyphonus*—the abdominal segments are coalesced, cannot readily be determined until more perfect remains have been discovered.

A supplement by Mr. Samuel H. Scudder gives figures and descriptions of eight genera and ten species of fossil insects from the coal of Illinois. As most of these new genera are established on very fragmentary evidence, they should be dealt with leniently; but beyond the fact, which they well establish, that Insect-life was rife in the Coal-period, they do not prove the presence of special families of Insects quite to the satisfaction of the Entomologist. We do not intend, however, by this to disparage the value of Mr. Scudder's labours, as we are well aware of the difficulties he has to contend with in his researches.

The Australian papers have shown, from time to time, that the Legislative Assembly of Victoria was in a very unsettled state of mind upon most questions of internal policy which it was called upon to discuss, and the Ministerial party seemed usually to be in a minority, whichever side happened to be in office. The stoppage of supplies was a favourite method of carrying on political war, the paid officials thereby suffering temporary inconvenience for the sake of their leaders.

But that this learned body should, in its wisdom, decide that the Geological Survey of the Colony of Victoria—conducted thus far so ably by Mr. Alfred R. C. Selwyn and his staff—should for the present come to an end, and that these gentlemen should be paid off and sent home to England, seems incredible, did we not learn it from the best authority. Henceforth Mining and Mineral Surveying will alone be considered; but the completion of those beautiful maps—some of which were exhibited by Mr. H. M. Jenkins at Norwich, in illustration of his paper "On the Tertiary Deposits of Victoria"*—will, we fear, now be a far distant event. Strange that the presence of the noble metal, GOLD, should render men so shortsighted—nay, blind—to the best interests of the Colony, as to decide that its geological resources shall remain unmapped and unexplored. Has there arisen a rival geological prophet who objects to Mr. Selwyn's observations on the age of true Auriferous Quartz-reefs because he had a non-auriferous quartz-reef for sale?†

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* See 'Quart. Journ. Geol. Soc.,' vol. xvi., p. 268.

† See 'Trans. Geol. Soc. Glasgow,' vol. ii., p. 234, Pl. III.

‡ 'Quart. Journ. Geol. Soc.,' vol. xix., p. 84, Fig. 8.

Fossil Botany.—Mr. R. H. Scott, M.A., F.G.S. (who obtained from the Council of the British Association a grant of 100*l.* in aid of the exploration of the Greenland Plant-bed), has just forwarded to the British Museum a series of the leaf-impressions from Atanekerdluk, W. Greenland, collected by E. Whymper, Esq., and described by Dr. Oswald Heer, in his '*Flora fossilis Arctica.*'‡

Another series of leaf-impressions from the Pipe-clay Bed (Lower Bagshot), Alum Bay, Isle of Wight, collected by W. Stephen Mitchell, M.A., F.G.S., also under a grant from the British Association, have likewise been placed in the British Museum.

The collection of leaves most nearly resembling the Greenland series are from the Miocene Tertiary Fire-clay deposit, overlying the celebrated burning coal-seam on the Mackenzie River, near to the Great Bear Lake, described by the late Sir John Richardson, the leader of the Boat-expedition in search of Sir John Franklin.

Obituary Notices.—All geologists will sympathize with the "Old Silurian Chief" in the loss of Lady Murchison, though she has gone from us in the fulness of years and honours.

Her scientific attainments and abilities as a naturalist were well known, and it has always been Sir Roderick's pleasure to attribute to Lady Murchison's influence his first pursuit of geology as a study, and his subsequent success to her unfailing sympathy and support.

The Irish branch of the Geological Survey of Great Britain has received a severe check, in the loss by death of Mr. George V. Du Noyer, M.R.I.A., F.R.G.S.I., &c., District Surveyor of H. M. Geological Survey in Ireland. His work, commencing as it did under the late General Portlock, extends over nearly thirty years. His pen and pencil have aided in the task of completing forty-eight sheets of the Map of Ireland. He was an admirable draughtsman, and his sketches are well known among geologists and archæologists. He was carried off suddenly by fever, on January 3rd, at Antrim, greatly to the regret of his numerous friends. He leaves a widow and three children unprovided for.

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* 'British Association Reports.' Norwich, 1868. Section C.

† See 'Geol. Mag.,' 1866, vol. iii., p. 457 and p. 561.

‡ Die Fossile Flora der Polarländer von Dr. O. Heer. Zurich, 1868, 4to, pp. 192 (50 plates).

Among the great men who have dropped from the geological ranks during the last year must be mentioned Dr. Hörne's, of the K.K. Mineralien-Cabinet, Vienna. His work on 'The Molluscan Fauna of the Vienna Tertiary Basin' is unrivalled, and the death of its author just as it was arriving at its completion will be deeply regretted.

Principal Forbes, of St. Andrew's, was a man who justly held a high position among men of science. He was a F.R.S. of London and Edinburgh: and his books and papers on 'Heat,' 'The Theory of Glaciers;' 'Travels in the Alps of Savoy;' 'Norway and its Glaciers,' have exercised no little influence on Physical Geology.

The Rev. S. W. King, M.A., F.S.A., F.G.S., of Saxlingham, near Norwich, whose labours in the Crag and Norfolk Forest-bed have resulted in a fine collection of Mammalian remains, now placed in the Jermyn Street Museum.

Nor should we pass over poor old John Ruthven, the author of a geological map of the Lake Country, and the faithful companion and humble friend of Professor Sedgwick in his many geological rambles in the Skiddaw Slate District.

Geology is largely indebted to such native talent in almost every part of our island for some of the best chapters of its history.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

Since our last Chronicle was written, Mr. Henry M. Jenkins, F.G.S., Assistant Secretary to this Society during the past six years, and Sub-editor of this Journal, having been elected to the post of Secretary and Editor to the Royal Agricultural Society of England, has retired; and Mr. W. S. Dallas (for ten years Curator to the Yorkshire Philosophical Society's Museum, York), has been appointed in his stead. The February number of the Proceedings, however, is edited by Mr. H. M. Jenkins. It contains nine papers published in full, and six in abstract, besides several translations of foreign papers.

Among these papers are several which have been postponed:—(1.) Mr. G. W. Ormerod has a short notice of the probable occurrence of the "Water-stone Beds" of the Keuper (containing pseudomorphous crystals of Chloride of Sodium) in the counties of Somerset and Devon.

(2.) Messrs. J. W. Salter and Henry Hicks contribute descriptions of five new species of Trilobites, from the "Menevian Group," St. David's, belonging to the genera *Conocoryphe* and *Paradoxides*, illustrated by two 8vo plates.

(3.) Mr. Alfred Tylor, F.G.S., describes the Quaternary Gravels of the Aire Valley at Bingley, of the Taff Vale, of the Valley of the Rhonda, the Cave-section (called Bacon Hole) Gower, and the sections at Crayford, Erith, and Salisbury, and he compares the angles of deposition of Gravel-beds concealing the escarpment of the Chalk in these last three localities with the escarpment at Brighton and Sangatte.

The bulk and height of the Quaternary deposits had strengthened the conviction which he expressed in his paper on the Amiens Gravel,* (1) That there was a long period, reaching nearly to the Historical epoch, in which the rainfall was excessive, and which he termed the "Pluvial Period."

(2) That the ice-action (of which there is evidence) was subordinate to the aqueous action.

(3) That the fossiliferous Quaternary deposits have been best preserved where they have been formed in cavities lying between the edge of the bank of a river, estuary, or sea, and an escarpment running parallel with it at no great distance.

(4) That the immediate source of the gravels was the high lands adjoining the rivers, whence they had been washed down by rain, with the assistance of lateral streams, into the lower ground, where they had come in contact with larger quantities of running water, had been mixed with rolled materials, and spread in thick beds over the bottoms and slopes of valleys or the sides of escarpments.

(5) The escarpment is usually concealed under a coating of gravel or loess.

Mr. Tylor argues that with a rainfall such as we now have it would be impossible that such widely-extended gravel-beds could be spread over an extensive area, and reach to a height more than 150 feet above the level of the Thames. It is equally impossible, he thinks, for the present volume of the Thames to have produced fluviatile beds at all equivalent in size to those of the ancient Thames.

That the condition of the beds, which rise above the 50-feet level, points rather to pluvial than to fluvial action.

Mr. Tylor informs us there are no traces of marine remains in the Thames-valley gravels. Assuming that they are of marine origin, gravel-banks are not the safe depositories of organic remains. A walk along the Chesil Bank, or the Shingle-beach at Weybourn on the Norfolk coast, would teach this in an hour. As well might we expect to find grains of wheat preserved between millstones.

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* See 'Quart. Journ. Geol. Soc.,' vol. xxiv., 1868, p. 103.

The gravel that fills a valley is not necessarily the result of the excavation of the valley. It may have been cut out, then submerged beneath the sea—filled to the top with drift—once more re-elevated, and again scooped out, leaving remains of the old drift on its flanks.

To enable the Thames to reach the gravel-beds now more than 150 feet above its waters, we must have a subsidence of land to that extent, which would not only enable the Thames, but the sea itself, to have a hand in rolling them over and remaking them.

We cannot deal here with the great mass of materials brought together in Mr. Tylor's paper, and as we rise from its perusal the feeling is strongly impressed upon us that he is not the "master-mind to whom is reserved the privilege, to whom is given the power, to construct from those fragmentary truths a systematic whole."*

(4.) The other postponed paper, "On Flint Flakes from Carrickfergus and Larne," by G. V. Du Noyer, Esq., will be found noticed in the 'Chronicle of Archæology.'

The contents of the journal proper, that is to say, the papers belonging to the past quarter are:—

(1.) An announcement by Sir Roderick Murchison that the Russian geologists had ascertained that a large tract in Siberia, between the rivers Lena and Jenissei, is composed of Upper Silurian rocks and Carboniferous rocks, containing coal-seams; with rocks of Oolitic and Liassic age, corresponding with those already examined in Russia. It thus appears that the vast, slightly undulating, and, to a great extent, horizontal and unbroken formations, each of which occupies so wide an area in European Russia, are repeated on the eastern side of the Ural Mountains. In this range of mountains only are to be found igneous and erupted rocks.

(2.) Professor Sandberger gives a section of a well at Kissingen through the Zechstein formation, the Bunter and Saliferous beds.

(3.) An abstract only of Mr. Tylor's paper on the 'Formation of Deltas, and on the Evidence and Cause of Great Changes in the Sea-level during the Glacial period.'

This is again a very complex paper, and is presented to the mind like a vast picture, painted by a patient artist who, however, lacked the necessary genius to group his figures and produce the effect he doubtless had in his mind at starting.

A paper treating of the formation of deltas; the parabolic curve of the beds of rivers; raised sea-breaches; the ice-cap at the poles, and reduction of the volume of the sea during the Glacial period; coral-reefs in the Pacific; the origin and age of the English Channel—is not to be taken in hand lightly; the paper is a failure, for the reason stated in the other case, the subject has mastered the author.

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* See Article VII., "The Scientific Year," 'Quart. Journ. of Science,' January, 1869, p. 74.

(4.) Mr. G. M. Browne records an earthquake-wave which appeared at Admiralty Bay, Island of Bequia, on 17th March, and advanced 3 feet in height, a distance from 70 to 350 feet beyond high-water mark. A second smaller wave followed.

(5.) Captain F. W. Hutton sends a note on an extinct Volcano (Nga Tutura) in New Zealand, previously described by Mr. Heaphy.* Captain Hutton thinks the fluid matter that escaped as lava was not connected with any deep-seated matter in the interior, but may have come from rocks 1000 feet below the surface. We are glad to see Mr. David Forbes was present to condemn the rashness of such a statement made at hazard;—the idea of fluid rocks only 1000 feet below the surface is dreadful.

(6.) Mr. Wood Mason calls attention to the discovery of teeth of *Dakosaurus* in the Kimmeridge Clay of Shotover Hill. *Dakosaurus* had, however, previously been found at Potton, near Cambridge, and described by Mr. John F. Walker, B.A., F.G.S., in the 'Annals and Mag. Nat. Hist.,' 1866.

(7.) Dr. Duncan's paper on the Test of *Amphidetus* was withdrawn.

(8.) Mr. Bauerman's "Geological Reconnaissance in Arabia Petræa" is, we trust, the first only of a series of good papers on this interesting country. Hills of gravel-topped alluvium, gravel-plains, gently swelling or terraced plains of sand, a kind of oolite made up apparently of rolled fragments of shells, dipping sea-wards; blue shaly clays with gypsum; granular massive gypsum, or alabaster; cliffs of calcareous grit-stone finely stratified; white chalky limestone; a bluish grey or white crystalline (Tertiary) limestone, and a soft limestone (these last bearing Nummulites), a series (600 feet thick) of Lower Cretaceous rocks, and of dark-red soft sandstone, with marly partings (like the Lower New Red Sandstone about Chester), these are the principal formations met with.

Old mines were observed in several places in a bed of iron and manganese, and remains of copper-works of considerable extent. Turquoise-mining has been carried on by the late Major Macdonald, and subsequently by a Frenchman with more or less success. The implements of still earlier miners, discovered by Mr. Bauerman, are recorded in the Chronicle of Prehistoric Archæology.

(9.) Dr. Le Neve Foster and Mr. Bauerman have a joint note on the occurrence of Celestine in the Nummulitic Limestone of Egypt. The Celestine occurs not only in detached crystals, but also, filling the interior of fossil shells, especially the chambers of *Nautili.*

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* 'Quart. Journ. Geol. Soc.,' 1859.

(10.) Dr. Duncan adds a note on the Echinodermata, Bivalve Mollusca, &c., from the Cretaceous rocks of Sinai. The list shows that thirteen out of twenty-four species are common to the North African and Sinaitic Cretaceous rocks, and that eight others are well-known European forms.

(11.) M. Charles Martins describes the evidence on which he concludes that a Glacier during the Quarternary Period occupied the Valley of Palhères, in the Lozère.

At the Annual General Meeting of the Society, the President (Professor T. H. Huxley, LL.D., F.R.S.), presented the Wollaston Gold Medal to Henry Clifton Sorby, Esq., F.R.S., as a mark of the Society's appreciation of his researches into the structure of rocks, minerals, and meteorites, and the investigation of the phenomena of Slaty Cleavage. He also handed the balance of the proceeds of the Wollaston Donation Fund to William Carruthers, Esq., F.L.S., F.G.S. of the British Museum, in aid of his researches in Fossil Botany, in which branch of study he has already added so much to our knowledge.

8. METEOROLOGY.

The Pilot Charts for the Atlantic, alluded to in our last number, are the first instalment of a systematic series of representations of the physical phenomena of the ocean which are promised by the Hydrographic Office of the Admiralty. In the advertisement prefixed to the work, Captain Richards explains that, from their very nature, these charts cannot be offered with the same confidence or authority as the charts on which depend the safety of navigation. They are in fact only intended to furnish hints to the seaman in shaping his course. All available sources of information, both British and foreign, have been consulted in their preparation, so that the charts may be fairly considered as a record of the present extent of our knowledge of ocean meteorology, in the particulars of which they treat.

They consist of four wind-charts, corresponding to the different seasons, a current chart and an ice chart of the Southern Hemisphere.

On the wind-charts the percentages of prevailing winds are represented by means of stars, for spaces varying in size from ten-degree squares in the heart of the S.E. trade-wind to two-degree squares off Cape Horn. The number of gales from each point per month is also given, and on the coasts some useful practical remarks as to the weather which may be expected there. Other notices concerning meteorological phenomena generally are to be found in the form of notes, while the limits of certain districts, such as those of the trade-winds, the equatorial rainfall, &c., are laid down by curves. These wind-charts are most useful of their kind, and far more intelligible than those which have formerly appeared in this country and the United States; but in certain parts of the ocean more specific information as to both date and place is undoubtedly required. Though for the S.E. trade the means of ten-degree squares for three months may suffice amply, we require for other parts at the least monthly means for much smaller areas, such as those given on Adm. Chabanne's charts for the coast of Brazil, published by the Département de la Marine in Paris in 1861.

The current chart gives a graphical representation of the general course of the chief currents throughout the year, with notes showing how their set on each coast is affected either by the winds or by other disturbing causes. The course of the principal isothermal lines of surface temperature is also given, as well as entries of the most remarkable deep-sea soundings.

In the atlas is included the ice chart of the Southern Hemisphere, which appeared about three years ago. The urgent necessity for such a chart became very obvious when the introduction of great circle sailing brought prominently before the notice of navigators the dangers to be experienced from ice in high southern latitudes.

The whole atlas is a most useful work, and shows on its face the care and labour which have been spent on its compilation; we shall be glad to see the similar series for the Indian and Pacific Oceans.

With reference to the subject of sea-temperature, and more especially of that prevailing at great depths, the report recently submitted to the Royal Society by Dr. Carpenter and Dr. Wyville Thomson is of great interest and importance. These gentlemen wishing to test, by direct experiment, the truth of the assertions made by the late Edward Forbes, as to the depth in the sea at which organic life ceased to exist, and on which statements considerable doubt had been thrown by the soundings made by M'Clintock, in the 'Bulldog,' and by others, obtained the use of H.M.S. 'Lightning,' and proceeded last autumn on a cruise off the west coast of Scotland. The results as to the precise biological question above referred to, which were obtained by the expedition, do not belong to the present subject, but the observations on temperatures at great depths merit particular notice.

It is well known that an idea has been nearly universally accepted, that the sea-bottom at great depths was covered by a stratum of water possessing a temperature of 39°·5. In low latitudes this stratum was said to be covered by water warmer than its own; in high, by water colder. This view carried with it the support of so eminent a man as Sir J. Herschel, in his various writings on Meteorology and Physical Geography. This temperature of 39°·5 is, however, that of the maximum density of *fresh* water; whereas the behaviour of saline solutions is very different from that of fresh water under similar circumstances. The direct experiments of Despretz on sea water, brought from the South Pacific by Freycinet, established beyond a doubt the following facts:—

The density of the water at 68° F. was 1·0273 under ordinary circumstances, *i. e.* if slightly agitated, it froze at 27°·4; but if it were cooled very carefully, a maximum density was reached at 25°·4.

Subsequent to Despretz's experiments, which were published in the 'Comptes Rendus' for 1837, Sir J. Ross, in his Antarctic Expedition, tested the temperature at various depths, but failed to ascertain the existence of any water at a lower temperature than 39°. However, long anterior to this date, General Sabine had obtained evidence in the Arctic regions of the existence of water at a temperature much below 32°, at depths of 700 fathoms or so. Recent observations by Captain Shortland in the Indian Ocean have led to similar results.

The instruments, however, which have hitherto been used were eminently untrustworthy, the indices, especially of the maximum thermometer, being extremely liable to displacement by a jar, so that frequently a temperature was recorded as maximum which was not as high as the surface temperature. Such a fact as this throws discredit on the observations of minimum temperature made by the same instrument. In addition, these thermometers are liable to be deranged if they are even laid in a horizontal position; so what are we to expect when the sounding line brings them up, as it sometimes does, in a reversed position! However, during the past year, the Hydrographic Office has paid particular attention to the improvement of these thermometers, and the 'Lightning' was accordingly furnished with the new pattern instruments, several of which were brought home in good order, so that the results furnished by them merit especial credit.

The chief fact as to temperature ascertained by the expedition is the existence, over a certain area between the Faroe and Orkney Islands, of water possessing a temperature of about 32° at a depth of 500 fathoms, while in other soundings taken in the adjacent districts, the temperature at equal or even greater depths was persistently registered above 45°. On one occasion, within the cold area, bottom was found at 140 fathoms, and the minimum temperature recorded was 41°·7, showing the decrease in temperature to be progressive with the depth. Each of the areas was characterized by the presence of special organisms, leading to the conclusion that the distribution of animal life is more closely related to the *temperature* than to the *depth* of the sea. However, the results of the sixteen soundings made by this expedition must be considered as merely tentative; and we can only hope that the present Board of Admiralty will give as cordial countenance to the inquiry as their predecessors did, now that it has been shown, as Dr. Carpenter observes, "that within a short distance of the northern coast of Scotland an opportunity is presented for determining with great precision the physical conditions of two opposing currents with a difference of temperature of at least 15°." This determination is not, by any means, as simple a matter as it may seem. Deep-sea sounding is no child's play, and when we have to ascertain thereby not only the depth of the sea, but the existence, the course, the limits, and the physical conditions of submarine currents, the problem becomes one of extreme difficulty; and we shall look with great interest to the attempts made to effect its solution.

While we are on the subject of ocean currents, a book recently published by Mr. Jordan,* calls for special notice. In this work the author proceeds, as he says himself:—"Firstly, by theoretical deduction, to demonstrate hypothetically the action of *vis inertiæ*.

"Secondly, by practical investigation, to ascertain whether or not there exist in the ocean such movements as may, in the first part, be demonstrated to be the natural result of the action of *vis inertiæ*."

In the first book the theoretical effect of the principle, as brought into action by the rotation of the earth on its axis, and by its annual orbital motion, is examined. In this portion, though we may allow the truth of a good deal that Mr. Jordan says, we must say that more actual proofs are required before we can admit the existence of perpendicular and inclined circulations in the ocean, such as he supposes to exist. We are hardly prepared to attribute the circumstance that the tendency of an equatorial current of air is to lower, while that of a polar is to raise, barometrical readings, to the fact that while the former is, in virtue of its nature, an ascending current, the latter is a descending one.

The question of ascending and descending currents requires investigation, but we are decidedly disposed to believe that not unfrequently the south-west wind descends to the earth, *e. g.* at the edge of the trade winds, while the north-east wind at times rises from it.

Some of the diagrams of ocean circulation given by the author are extremely pretty as representations of osculating curves, but we want more positive facts in support of them before they can be accepted as final explanations.

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* 'A Treatise on the Action of Vis Inertiæ in the Ocean, with Remarks on the Abstract Nature of the Forces of Vis Inertiæ and Gravitation, and a new Theory of the Tides.' By W. Leighton Jordan, F.R.G.S. London: Longmans.

In Book II. we have the investigation of ocean currents, which are all attributed to the action of *vis inertiæ*, but here the author's hobby runs away with him a little, for at page 105 he says:—

"Why, if the trade-winds result from the heating action of the sun, they should continue to blow at night just as in the daytime, is, it appears to me, not easy to understand."

The action of a heated surface in causing an ascending current of air does not cease at nightfall over large areas like Central Asia, as it does in the case of small islands, where the diurnal alternation of land and sea breezes holds good. An extensive circulation of air, once set going, is not easily diverted into other channels. However, the monsoons and coast winds in general offer a serious objection to Mr. Jordan's views, and are in favour of the interpretation generally received.

Book III. treats of *vis inertiæ* and gravitation; and here at the outset we are met by a new principle—*evanescence*. "In this term comprehending the unknown laws which control matter throughout its existence, and by it inferring that matter has not always existed, and that in course of time it will cease to exist; presuming, of course, that it is only reasonable to suppose that something immaterial existed from which it had its origin, and that when it has run its course and ceased to exist something immaterial evolved from it will exist after it."

Not having seen the author's other work, 'The Elements,' we are at present unable to understand how he proposes to create matter.

The chapter on tides is happier, and the explanation of the retardation of spring and neap tides respectively for a day or two after the moon's changes have taken place is clear and intelligible.

There is one very serious objection to the book as a whole—the style is confused to the last degree, and it is often necessary to read a page two or three times to make sure that you have caught the author's meaning. When he is stating two alternatives, each is given at full length, so that the occasional use of the words, "and *vice versâ*" would have reduced the size of the book by at least twenty pages, and made it much more intelligible.

In the last Chronicle we referred briefly to the synoptic charts of the Indian Ocean, submitted to the British Association by Mr. Meldrum, Secretary of the Meteorological Society of the Mauritius. These charts present some features of great interest when compared with those issued by Le Verrier for the North Atlantic. Mr. Meldrum's long experience of the weather of those seas renders whatever he may say about it well worthy of attention. However, in these charts he allows the facts to speak for themselves, not drawing isobaric lines unless their course is fully justified by observations. In every case he enters these latter, pure and simple, omitting the barometrical readings, unless he is thoroughly satisfied as to their correctness: accordingly the charts are chiefly representations of wind and weather. The region with which he has to deal is in some respects easier to manage than that of the North Atlantic, because the areas of the monsoons and other prevailing winds are clearly and sharply defined. In some of them Mr. Meldrum has been able to trace cyclones from their origin at the southern edge of the N.W. monsoon, rotating *with* the hands of a watch; while in high southern latitudes he finds the wind at times moving in the opposite direction round a relative barometrical maximum, forming what Galton calls "Anticyclones." Both these motions are of course opposite to what obtains in the Northern Hemisphere. It is sincerely to be hoped that Mr. Meldrum will carry out his intention of issuing these charts for a considerable period of time, so that weather may be traced consecutively from day to day. We should say that the *time* on the charts is noon for the meridian of 60° E., being the central meridian of the charts.

The most important paper which has appeared of late in the journals of our home Societies has been one of which the subject is somewhat cognate to what has just been described—we mean Mr. Buchan's investigation of some American storms, published in the October number of the 'Journal of the Scottish Meteorological Society.' In this paper, which is illustrated by three charts for March 16, 18, and 19, 1861, we are presented, not only with the atmospherical conditions of half the Northern Hemisphere, north of the parallel of 30° N., but also with the tracks of certain storms, some of which he has traced across the Atlantic Ocean. The charts have precisely the faults which have been avoided in those just noticed, *viz.* that the isobaric lines are drawn with a free hand and on insufficient data, so that the attention is distracted from the observations themselves to the interpretation given of them by the author of the paper. If the line of inquiry thus undertaken by Mr. Buchan be followed out by him, and the fact that storms do occasionally cross the Atlantic be placed beyond the possibility of cavil, a great step will have been made; but in the theoretical explanation given of the storms we regret to find a vagueness of reasoning, which is a very serious defect, and leads us to doubt the probability of his proving his case satisfactorily. Thus he reiterates the old idea that the latent heat set free by condensation of aqueous vapour has a material effect in reducing atmospherical pressure, without justifying the statement by any calculation whatever. He also adheres to the belief that the rotation of the air in a cyclone is caused by the diurnal rotation of the earth, whereas the opposite to this has been shown to be the case. In a cyclone in the Northern Hemisphere, on one side, the wind in its motion round the central area "backs" from south towards south-east, and on the other side it backs from north towards north-west; whereas the effect of the earth's rotation on a southerly wind flowing pole-wards is to give it westing, in consequence of its change of latitude, and the wind therefore "veers" towards south-west and west, forming not a cyclone but an anti-cyclone.

This carelessness of language is most unfortunate, as it mars much of the valuable work Mr. Buchan is doing. In one of his later papers he asserts that the air is composed of oxygen and hydrogen, while in the last edition of his 'Handy Book of Meteorology' he proposes that each missionary should be instructed in meteorology, in order to issue storm warnings for the South Sea Islanders, "and legitimately increase his influence over them!"

9. MINERALOGY.

Considering the extensive employment of that large class of ornamental stones grouped together under the general name of *Agate*, it is surprising how little is commonly known in this country as to the source whence they are obtained, and the manner in which they are worked. A small district at the southern foot of the Hundsrück, in Western Germany, has for more than four centuries been almost exclusively the seat of the agate trade, and at the present time upwards of 3000 of the inhabitants gain a livelihood by this peculiar branch of industry. Full information on all that relates to the subject of agates has lately been published by Herr Lange, who writes from the little town of Idar, situated in the very centre of the agate works.*

Agates usually occur in the form of amygdaloidal nodules, of greater or less size, embedded in a dark-coloured trap-rock or melaphyre. Many are the theories that have been advanced to explain the origin of these nodules, since the time when it was first suggested that they were petrified melons! At the present day it is generally supposed that the cavities now filled with agate were produced by the disengagement of gas or steam when the melaphyre was in a viscous condition. After the solidification of the lava-like mass, the cavities were gradually filled, either partially or completely, by silica held in solution by the water percolating through the rock. The precise manner in which the silica was introduced is a question still open to discussion. Some suppose that the solution transuded through the walls of the entire cavity, whilst others argue in favour of a local infiltration confined to special inlets, which are often exposed on cutting a section of an agate. Probably both theories may be advantageously combined; the deposit of "green-earth" which commonly lines the smaller cavities being due to a general percolation through the walls, whilst the solution of silica was introduced through definite channels or inlets of infiltration. It is difficult, however, with either theory to explain satisfactorily the formation of a regular succession of concentric layers lining the internal walls of a cavity, and not deposited simply upon its floor; whilst it is still more difficult to understand the conditions under which concentric layers were deposited at one time and horizontal layers at another—conditions which must have obtained during the formation of many of the so-called "Brazilian agates," which exhibit both deposits in the same stone. According to Reusch, the successive layers have been deposited from a solution which was alternately forced into and expelled from the cavities by the action of intermittent thermal springs. A modification of this theory is that adopted by our author. He supposes that the solution, after having deposited gelatinous silica in the cavity, was heated to its boiling point, and that the elastic force of the steam thus generated would press the siliceous jelly equally against all sides of the cavity, so as to produce a layer of uniform thickness throughout. The compressed steam would then slowly make its exit by perforating a passage through the successive layers; but if this outlet became sufficiently large, the steam might escape before acquiring sufficient tension to keep the gelatinous mass distended against the walls, and hence the silica, left to the force of gravity, would be deposited in horizontal layers upon the floor. In this way the author attempts to explain the alternation of concentric and horizontal deposits in the same cavity—a point which has hitherto been a standing enigma in all theories on the formation of agates.

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* 'Die Halbedelsteine aus der Familie der Quarze, und die Geschichte der Achatindustrie.' Von G. Lange in Jdar. Kreuznach, 1868. Pp. 100.

The occurrence of beautiful agates in the melaphyre of the Saarbruck coal-field led at an early period to the localization of the agate trade in the neighbourhood of Oberstein and Idar. Although for many years past no agates have been quarried in that locality, all the fine stones being imported from Uruguay, the trade of cutting and polishing still remains active, and at the present time there are 183 mills in the district, carrying 724 grinding stones; each double mill being reckoned as two single ones.

In the Chronicles of Mineralogy for July last, attention was directed to a remarkable shower of meteorites near Pultusk, in Poland.* Many thousands, not to say hundreds of thousands, of these stones fell within a very limited area, and thus ample opportunity was furnished of collecting specimens. A large number of these have lately been examined by Vom Rath, who shows that they consist of about 86 per cent. of silicates—probably Olivine and Shepardite—associated with 10 per cent. of nickeliferous iron, and nearly 4 per cent. of magnetic pyrites, together with a small percentage of chrome iron-ore.*

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* 'Quart. Journ. of Science,' vol. v., p. 419.

Although copper-pyrites is the most widely diffused of our copper-ores, it is by no means common to meet with well-defined crystals; and hence observations upon its crystalline forms are of much value. Formerly the mineral was referred to the cubic system, but in 1822 Haidinger showed, by measurement of the fundamental octohedron, that it must be removed to the tetragonal system. Herr Sadebeck, of Berlin, has paid considerable attention to the crystallography of this species, and has recently published the results of his study.† He first separates the two opposite tetrahedra, or hemihedral forms of the tetragonal octohedron, distinguishing them as tetrahedra of the first and second orders respectively. He then discusses the laws according to which twins are combined—a point of considerable interest, since twins of this mineral are much more common than simple crystals. Finally, he gives the characters of typical forms from different localities, and shows that these are in many cases so peculiar, as to enable the mineralogist, by a study of form alone, to refer a given crystal to its original locality.

Every collector must be familar with the beautiful crystals of limpid quartz, which, in company with calcareous spar, line many of the drusy cavities in the famous snow-white marble quarried at Carrara. More than 200 specimens from these quarries have been examined by Dr. Scharff, who has lately published a paper on their irregularities of growth.‡ He shows that the crystals, although apparently simple, are in many cases formed by the union of several individuals, by which the aggregate crystals possess an apparent rhombohedral cleavage. The two opposite rhombohedra, forming together the six-sided pyramid that caps each crystal, are often developed to a very unequal extent; the faces of the positive rhombohedron being enlarged at the expense of the corresponding negative form.

Dioptase—a beautiful and rare silicate of copper found in the wilds of the Kirghese Steppes, and so strongly resembling the emerald as occasionally to be mistaken for that gem—has recently been subjected to chemical examination by Herr Rammelsberg.[*] From the behaviour of the mineral when exposed to heat, he infers that the molecule of water which it contains is present in a state of true chemical combination, and not simply as water of crystallization. The formula of dioptase thus becomes

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* Leonhard und Geinitz's 'Neues Jahrbuch.' 1869. Heft I., p. 80.

† Zeitschrift der deutschen geologischen Gesellschaft. Band xx. Heft III., p. 395.

‡ Leonhard und Geinitz's 'Jahrbuch für Mineralogie,' u.s.w. 1868. Heft VII., p. 822.

$$H_2\,Cu\,Si\,O_4$$

and the mineral is therefore isomorphous with the two corresponding hexagonal silicates, Willemite and Phenakite, the former containing $Zn_2\,Si\,O_4$, and the latter $Be_2\,Si\,O_4$.

Some time ago we had occasion to notice the discovery of a native hydrous arseniate of zinc from Chile, described under the name of *Adamite*.[†] This species has lately been obtained by Messrs. Gory and Boutigny from a small copper mine worked in the Keuper sandstone of Cape Garonne in the Dépt. du Var. The French adamite occurs in the form of lenticular crystals or thin plates on the walls of fissures traversing a quartzose rock, and is associated with the two arseniates, olivenite and cobalt bloom; the latter imparts a reddish tint to many of the crystals, which otherwise present a greyish colour.[‡]

In compliment to Professor Laxmann, the Siberian traveller, the name of *Laxmannite* is proposed by M. A. E. Nordenskjöld for a new mineral discovered at Beresow, in Siberia.[§] It appears to be a chromate and phosphate of lead and copper; its chemical composition being represented by the following formula, where $RO = PbO + Cu\,O$:

$$3\,(\tfrac{2}{3}\,RO,\ \tfrac{1}{3}\,HO)\,PO_5 + 2\,(3\,RO,\ 2\,Cr\,O_3).$$

The component minerals of some of our Cornish granites have lately been examined by the Rev. Dr. Haughton.[‖] He finds that these rocks contain two felspars and two micas; the felspars, he refers to the species orthoclase and albite, and the micas to lepidolite and lepidomelane. Dr. Haughton supposes that these constituents are common to all the granites of Cornwall and Devon, which thus bear a close resemblance in mineralogical composition to the granites of Leinster and Mourne.

Analyses of two titaniferous magnetites from Norway have been published by Mr. David Forbes;[¶] and a large number of chrome iron-ores have been chemically examined by M. J. Clouet, whose memoir on these minerals is supplemented by a note in which

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[*] Zeitschrift d. deutsch. geolog. Gesellsch. Bd. xx., p. 536.

[†] 'Quart. Journ. Science,' vol. iii., p. 427.

[‡] 'Comptes Rendus,' Dec. 7, 1868, p. 1124. 'Geol. Mag.,' Feb., 1869, p. 79.

[§] 'Journal für praktische Chemie.' Band cv., No. 22, p. 335.

[‖] 'Proc. Royal Society,' vol. xvii., No. 108, p. 209.

[¶] 'Chemical News,' Dec. 11, 1868, p. 275.

M. E. Peligot points out the many relations that subsist between chrome iron-ore and magnetic oxide of iron.*

Von Lasaulx announces the discovery of tridymite in trachytic nodules occurring in a kind of hornstone rock from Alleret, in the department of Haute-Loire.†

One of Dr. Blum's valuable contributions to the study of pseudomorphism has recently appeared,‡ and contains the results of his observations on materials that have accumulated since his last publication.

Several new Swedish minerals have been described by C. W. Blomstrand from near Westanå, in Schonen.§ Most of these are hydrous phosphates of alumina, more or less akin to Wavellite. They have received the names of *Berlinite*, *Trolleite*, *Augelite*, *Attakolite*, and *Kirrolite*. A hydrous silicate of alumina, named *Westanite*, has the following composition:—

$$2\ Al_2\ O_3 \,.\, 3\ Si\ O_2 + HO.$$

Dr. Petersen of Darmstadt applies the name of *Hydrotachylyte* to an amorphous mineral found in the basalt of Rossdorf, near Darmstadt.|| It is a hydrous silicate containing alumina, sesquioxide of iron, potash, soda, magnesia, lime, and the protoxides of iron and manganese. A portion of the silica is apparently replaced by titanic acid.

10. MINING, METALLURGY, AND RECENT LITERATURE.

MINING.

THE Stannary Court of Cornwall and Devonshire is nearly the oldest—if not actually the oldest—court existing in this country, with almost all its original constitution preserved, and with its forms unaltered. Dating from the time of John, who granted a charter of special privileges to the tinners, and taking a more perfect organization in the third year of Edward I., the Court of the Stannaries has remained until now without any special alteration. Carew tells us that "upon suit made to Edmonde, Earl of Cornwale, sonne to Richard, King of the Romans, they obtained from him a charter with sundrie privileges; amongst which it was granted them to keep a court and hold plea of all actions (life, lymme, and land excepted), in consideration whereof the said lords

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* 'Annales de Chimie et de Physique,' Jan., 1869, pp. 90, 100.

† Leonhard und Geinitz's 'Jahrbuch.' 1869. Heft I., p. 67.

‡ Leonhard und Geinitz's 'Jahrbuch.' 1868. Heft VII., p. 805.

§ 'Journal für praktische Chimie.' Bd. cv., No. 22, p. 337.

|| Leonhard u. Geinitz's 'Jahrbuch,' 1869, p. 32.

accorded to pay the Earl a halfpenny for every pound of tynne which should be wrought," &c. At the head of this court is a Lord Warden—now the Duke of Cornwall—who appoints his Vice-Warden, by whom the courts are held.

This ancient Mining Court is now about to undergo—perhaps not too soon—material modification; and on the evening of Friday, the 26th February, Mr. John St. Aubyn, one of the members of Parliament for West Cornwall, obtained leave to introduce a bill to the House of Commons "*for amending the law relating to Mining partnerships within the Stannaries of Devon and Cornwall and to the Court of the Vice-Warden of the Stannaries.*" This involves so important a change in the laws which relate to mining in the West of England, that, although this Journal is not the place for discussing the questions at issue, it appears necessary to record the intended alterations in our mining chronicles.

From time to time various suggestions have been made relative to the organization of some system by which a provision might be secured for the widows and children of such coal-miners as may perish in the course of their labours. A plan of colliery insurance has been more than once proposed, and there is but little doubt that it would have been long since established had the period been a more auspicious one for commercial speculation.

The project for organizing a Colliery Insurance Company, to embrace a provision for the survivors of those killed in colliery accidents, and to reimburse the colliery proprietor or worker for any loss accruing to his property, is again exciting attention. A letter has been published by Mr. Stephen Sleigh, of Austin Friars, which clearly shows the practicability of such a system of insurance. We learn from this letter that the value of the colliery property of Great Britain is estimated at 70,000,000*l.* sterling. The production of coal is at present 104,000,000 tons per annum, and in obtaining this, on the average of ten years, 1000 lives are lost in each year. It appears that 2*d.* per week per man would produce a fund from which 100*l.* could be given to the widows and children of the deceased collier; and that a very small premium, varying of course with the district, would secure the insurer from any serious loss to his property. As active measures are about to be taken to establish this most important principle, we content ourselves at present by directing attention to the movement.

In the House of Commons, on Thursday, February 25th, Mr. Greene asked the Secretary of State for the Home Department whether it was the intention of the Government to introduce any measure for the further prevention of accidents in coal-pits. He elicited the reply—that a measure on the subject was being prepared and would shortly be laid before the House. Mr. Kinnaird inquired if the Government intended to bring in a bill for the better regulation of metalliferous mines in accordance with the recommendations of the Mines Commission. The answer given by Mr. Knatchbull-Hugessen was curiously evasive; no bill was in preparation, but he hoped that legislation would not be long postponed. It is now nearly five years since the Commission, of which Lord Kinnaird was the President, made its report. In that report the Commissioners most strongly urged the necessity of some prompt legislative enactments, by which the more perfect working of the copper and tin mines might be secured and the lives of the men preserved. Nothing has, however, as yet been done, and during the long-continued depression of mining, things have been allowed to become gradually worse than they were when the Commission examined them. The whole system of working our copper and tin mines is so bad, that no hope can be indulged in of their improvement until the Legislature steps in, and by some well-considered measure protects alike the miner and the shareholder from the present destructive system.

Coal in the Colorado district is a matter of great importance. According to the 'Denver News,' General Pierce stated to the Board of Trade that besides the bed of 31 inches, discovered near Fort Dupton, on the Platte, there were also two beds on the Cache-la-Poudre. One of these beds was 4 feet thick, and the other about 18 inches. The 'Salina Herald' says that in digging a well on the east side of the Smoky Hill River—less than two miles from town—a bed of good bituminous coal, 18 inches thick and about 20 feet below the surface was cut through.

Coal-mining in France has, during the past year, been particularly active. This will be seen from the following statement of the production during each of the last six years:—

	Tons (Statute).		Tons (Statute).
1863	10,516,752	1866	11,807,142
1864	11,001,249	1867	11,975,164
1865	11,785,714	1868	12,345,000

The collieries of Belgium have not exhibited the same progressive increase. From the report of Mr. F. Jocham, Director of Mines in the province of Hainault (which is the last published authority on the production of coal in Belgium, we learn that to the end of 1867 the production was as follows:—

	1865.	1866.	1867.
Hainault	9,206,058	.. 9,831,424	.. 9,595,280
Namur	305,754	.. 358,687	.. 389,586
Liége	2,328,911	.. 2,564,551	.. 2,770,956
Total of the Kingdom in Metrical Tons	11,840,723	.. 12,754,662	.. 12,755,822

The copper mines of Africa have of late years been attracting considerable attention. The copper lodes in the Insizwa Mountain, about 12 miles from the southern boundary of Natal, are remarkable. Some comparatively small workings have been carried on about 80 miles from Port St. John. The deposit here is described as about 18 feet thick by 2½ feet in depth. From this description it is evidently not a *vein*, but a *bed*. This is clearly in a state of decomposition, since it is said the ore is replaced by a yellow ochreous deposit (*gossan* of miners) containing nodules of very pure carbonate of copper or malachite, varying in size from a pea to masses of 10 or 15 lbs. weight. Some miners from D'Urban penetrated deeper into the mountain, and again found a similar deposit. Portions of considerable masses have been found to contain as much as 56 per cent. of metal, the average, however, being from 30 to 40 per cent. Silver was found to the extent of 5·30 ounces to the ton of copper, and a trace of gold was detected.

Chromium is stated to have been discovered in large quantities in Maryland and Pennsylvania. Chromate of iron of fine quality has also been found in Victoria. We understand samples of this mineral and antimonial ores of good quality have been shipped to this country with a view to determining their real commercial value.

In a cave in the mountain of Galenstock, which it is well known separates the cantons of Berne and Urich, a valuable deposit of topaz has been recently found.

Tin mines in Siam are, on the authority of the 'Journal of the Society of Arts,' about to be worked. We quote the paragraph:—

"Another tin district is about to be opened at the Isthmus of Kra. The immense value of the tin-workings at Junk, Ceylon, or Phuket, supposed to be not less than 150,000 tons per annum, has incited a Chinese merchant to propose the active development of the Kra Mines, and as tin is supposed to abound along the whole range of the Malay peninsula there are many who believe in his success. He is to have the government of the district to enable him to carry out his designs. The river of Kra is the southern boundary between British Burmah and Siam."

Seeing that the annual production of tin is as follows:—

	Tons.
England	7,296
Banca	4,260
Billeton	1,900
Other parts	3,000
Total	16,456

—the 150,000 tons said to be produced at Junk is an evident absurdity. During the past year the Chinese merchants have been the largest buyers of British and Dutch tin, to which circumstance we owe the rapid rise in the price of tin which has lately taken place. This proves that they have not any great expectations of very considerable production of this valuable metal nearer home.

The prominence which has been given to technical education has led to a proposal to found a Professorship of Mining in the University of Glasgow; and a deputation has been in communication with Professors Ramsay and Huxley, of the Royal School of Mines, on the question of establishing a mining school in Wales. The experiments made already in Glasgow, at Bristol, and by Sir Charles Lemon, and others, in Cornwall, should teach the lesson that it is quite impossible for the miner to attend any fixed central school. The only practical and useful system of imparting instruction to the miners is that—adopted with great success by the Miners' Association of Cornwall and Devonshire, and by Mr. Daglish, in the neighbourhood of Seaham,—of sending the teacher to the miner, and giving him the advantages of a school of mines in the very midst of the district in which he labours.

GOLD.—The Nova Scotia gold-fields have produced during the past three years as follows:—

	Ounces.
1866	25,204
1867	27,314
1868	20,733

The production of the quartz-rocks of Merionethshire has fallen to 490 ounces in the period between October 1st, 1867, and December 31st, 1868.

There has been a small rush to certain gold-fields in Sutherlandshire. On a district not far from Helmsdale, which was known only to a few sportsmen and shepherds, recognized as the Kildonan Burn, a regular system of "Diggings" has been organized, and the burn has been christened as "Gold Creek." The results are not, however, satisfactory, since it appears that the most industrious gold-seeker cannot realize more than 5*s*. a-day.

METALLURGY.

Considerable differences of opinion still prevail as to the value of the Heaton steel-making process noticed in our last number. We have carefully read and considered all that has been said in favour of the process and against it. We are not by any means satisfied with the tone which has been assumed by those who have entered on the discussion of the question. Indeed, it is to be regretted that many of the statements which have been copied from paper to paper should ever have been made at all. They are obviously not consistent with our knowledge of the chemical changes effected in a mass of iron when subjected to the action of nitrate of soda. We have been informed by one of the largest of the Sheffield steel manufacturers that, while he waits to see the result of a continuance of the experiments carried on at Langley Mills before he adopts it, he is strongly predisposed in favour of the process—that he regards it hopefully, and—we are bound to say it—that he is greatly pleased with the liberality and openness observed by Mr. Heaton. With these remarks—which we introduce mainly to convince our readers that we are not inattentive to the experiments in question—we leave the Heaton steel process until its more complete development removes it from the doubtful position in which it has been placed by injudicious advocacy.

A discussion of some interest in connection with the Heaton process has been opened in the pages of 'The Chemical News.' It arises out of a paper read before the Chemical Society, by Dr. B. H. Paul, on "The Connection between the Mechanical Properties of Malleable Iron and Steel, and the Amount of Phosphorus they Contain." Mr. W. Mattieu Williams, of the "John Brown and Co., Limited" Works, Sheffield, argues that Dr. Paul has shown an imperfect knowledge of his subject. That although Dr. Paul's conclusion that 0·50 per cent. does not impair the quality of steel is correct when it applies "*to tenacity as measured by a direct and gradually applied longitudinal or axial strain*," yet, that it is absolutely wrong when it is made to refer to steel which is to be employed for cutting instruments of any kind. "It is obvious that the power of resisting a sudden, a vibratory, and a transverse shock is the property most demanded," and that here the smallest quantity of phosphorus is highly injurious—"this is just the property which phosphorus tends to destroy."

Chromium steel has been attracting some attention. An alloy of chrome and iron can be made of sufficient hardness to scratch glass. Experiments are stated to be in progress, on a large scale, as to the practicability of making a chromium steel for rails, by adding chrome iron-ore and manganese to the iron in the puddling furnace.

At Pittsburgh (United States) some apparently successful experiments have been made in substituting a purely chemical process for the operation of puddling. Into melted pig-iron crushed hematite iron-ore is thrown—the oxygen of the ore combines with the carbon of the iron, removing it. The metal thus obtained is said to yield a very good iron, upon re-heating and squeezing in the usual manner. We believe a process much like this has been tried in this country and abandoned.

WORKS ON MINING.—'*Under-ground Life; or, Mines and Miners*,' by L. Simonin, has been translated by Mr. H. W.

Bristow, F.R.S., and published in a very handsome volume by Messrs. Chapman and Hall. This is a book which could scarcely have been produced by an Englishman—the whole idea is essentially French—and it requires a Frenchman, with all a Frenchman's quick perceptions, and his love of exaggeration, to give form to the idea. Victor Hugo writes a clever romance—'The Toilers of the Sea;' and M. Simonin seizes on the idea, and writes a narrative of 'The Toilers of the Mine.'

"What he (Hugo) so happily calls the ἀναγκη, or irrepressible power of the Elements, addresses itself alike to the mariner and the miner, for each is the soldier of the deep, against whom the powers of nature wage at times their utmost fury." This paragraph gives the key to the whole book; and every action of the miner's life is seen through the medium which has been coloured by the influences of Victor Hugo's romance. The author professes to describe the struggle of the miner "in its reality, without exaggeration of any sort." This profession is not fulfilled, since every page of the original book is coloured beyond the truth; and with all the efforts made by the translator to subdue this sensational writing to a more sober tone, he has only partially succeeded in doing so.

'Under-ground Life' is, especially in its English form, nevertheless, a book full of interest; its interest depending upon the most graphic descriptions of the perils which attend all subterranean labours. Every detail of mining is fully and in most cases faithfully given; the tools, the lamps, the processes—from boring the ground in the search for coal, to the removal of the coal from its bed—are carefully described. The dangers which await the miner are drawn, as we have said, with a bold pencil; and, as in the drawings, so in the text, the explosion of fire-damp and of gunpowder, the inundation of a mine, or the collision of tubs in a shaft, becomes equally the subject of sensational drawing and writing.

After all, we are not certain whether in a book of this sort—a book intended for the public, and decorated to the extent which fits it for the drawing-room—the proper course has not been adopted, especially when the work was originally intended for the author's countrymen; and is now—with the interpolations on British Mining by the translator—produced as a popular Treatise on Mining.

M. Simonin naturally looks at mining from a French point of view; and, although he admits that mining in Great Britain is far more extensive than it is on the continent, he insists upon it, that the same amount of careful system is not observed in the English mines as is to be seen in the mines of France and Germany. Mr. Bristow, who has translated the book in a most creditable manner, and who has used considerable judgment in adapting it to the English reader, might have modified still further much that Simonin had written. The difficulty of doing this we fully admit, and its danger. Many of the chapters must have been entirely re-written; and then, indeed, the work would have been no longer a translation of Simonin's, but the production of the English geologist, founded on the idea of the French mining engineer.

No one desiring an account of all the mining countries of the world, and of the methods by which the exploration of mines are carried out, can find in any one volume so much instruction on these points as in this one. Commencing with coal-mining, M. Simonin proceeds to the consideration of metalliferous mining; and follows this by descriptions of the processes of washing for gold, the search for gems, &c.; each division of the subject being treated with considerable detail—as to methods of working, statistics of production, and the like. For the latter, the author is under considerable obligations to 'The Mineral Statistics of the United Kingdom.'

The whole is most amply illustrated, and the chromo-lithographic plates of the minerals are beautifully executed. We have never seen anything of the kind to equal them. The new maps of the mining fields of all countries, which have been executed especially for this work by Mr. James Jordan, are of peculiar excellence, and give a very high character to this essentially popular book on mining.

'*Industrie Minérale de la Province d'Hainault*,' a report by Mr. F. Jocham, the Director of Mines in that province, gives a very full account of the process of coal-mining. From this report we learn that the production of coal in Belgium has been falling off, as will be seen by reference to our Chronicles of Mining.

The returns for 1868 have not yet been completed. The falling off is attributed to the depressed state of trade and manufacture; and the Belgian coal-owners look hopefully to the future. Another book of considerable value is '*Etude sur la Houille du bassin de Liége*,' by Leon Jacques. In this work a very detailed description of the collieries of this division of the Belgian coal-fields is given.

'*On the Haulage of Coal*,'—being the report of the Committee appointed by the North of England Institute of Mining Engineers to investigate this subject,—which has just been published at Newcastle-on-Tyne. This is a work of pure experimental detail, of the utmost value to all who are concerned in raising coal.

11. PHYSICS.

LIGHT.—M. Janssen has forwarded a letter from Simla (Himalaya) to the French Academy of Sciences, in which, after giving further particulars respecting his discovery of the visibility of the spectra of the protuberances on the sun's disk in full sunshine, he describes an ingenious plan by which he expects to be able to see the actual prominences at any time. The principle consists in getting one of the luminous lines into the spectral field, and then rapidly rotating the spectroscope. As the length of the luminous line depends upon the height of that part of the protuberance which it represents, it is evident that the rotation will cause the line to vary with the different widths of the elevations; and if the rotation is sufficiently rapid, the permanence of the impression on the retina will produce an accurate representation of the protuberance under examination.

Whilst M. Janssen only suggests an ingenious method by which these prominences *may* be seen, Mr. Huggins has actually succeeded in seeing them, as our readers will have seen from our 'Chronicle of Astronomy.'

A very beautiful experiment in spectroscopy has been described by Dr. Wallner. He passes the rapid discharges of a Leyden jar through an ordinary Geissler tube, and examines the light by means of a spectroscope. If the length of the discharge is increased a little, the sodium line immediately appears; and with a proper length of spark the brilliancy of the sodium line far exceeds that of the spectrum of the gas. By further increasing the distance of the discharge, the calcium line is produced with such intensity that it cannot be seen to greater advantage by any other method known. Finally, if the length of the spark is again augmented, the phenomenon changes, the light in the tube assumes a dazzling splendour, this luminous line forms a continuous brilliant spectrum in which the spectroscope reveals a completely black line instead of the sodium line; this, therefore, is the artificial production of a Fraunhofer line.

Microscopists will read with interest a very simple method of preserving animal specimens for fine dissection. It is described by Dr. Alcock. The advantages of the plan are—very perfect preservation; no necessity for closing up, so that the specimen cannot be got at; no fear of losing a valuable dissection from accidental evaporation, as where spirit is used; lastly, cheapness. The method adopted is to prepare a saturated solution of corrosive sublimate in alcohol, and when a dissection in water is in progress, a small quantity, as half-a-teaspoonful, of the solution is to be added from day to day if the slightest appearance of putrefaction is observed, but no more of it is used than is absolutely necessary; and by the time the dissection is completed, the specimen has become imperishable from the union of the corrosive sublimate with the tissues, and it may then be kept in pure water, either open or mounted in the usual way.

The oxyhydrogen light, in which the burning jet of mixed gases is allowed to impinge on a piece of Zirconia instead of Lime, is gradually being introduced in Paris. The advantages of employing Zirconia are, that of all the known earthy oxides it is the only one which remains entirely unaltered when submitted to the action of the blowpipe fed by oxygen and hydrogen. Zirconia is also, of all the earthy oxides, the one which, when introduced into an oxyhydrogen flame, develops the most intense and the most fixed light.

All persons interested in optical researches will be glad to hear that Messrs. Chance are now making optical glass of a density of 4·4. Glass of this density has never before been prepared commercially in England, although we believe it has long been made and used in France.

HEAT.—M. Le Roux has made some experiments with the vapour of sodium, and examined its capability or incapability of passing through rock-salt. Two crucibles of rock-salt were prepared, a thin plate of the same substance placed between them, and in one of the cavities sodium was placed.

Notwithstanding a bright red heat maintained for several hours, the piece which was not in direct contact with the sodium vapour remained completely unaltered, even where it had been in contact with the plate already completely penetrated. Chloride of sodium is not attacked by the vapour of sodium, but soda corrodes it energetically. A very small quantity of soda suffices to hermetically seal two surfaces of rock-salt, sodium preserving its lustre for several months in a crucible of this kind. Potassium vapour does not attack its chloride, but it covers the chloride with a bright blue substance, in which, possibly, chemists recognize the suboxide of potassium.

Mr. W. P. Dexter has described a new gas-lamp for heating crucibles, &c. The ordinary Bunsen burner is known to act upon the surface of platinum vessels brought into contact with the inner line of the flame; the metal loses its polish, becoming superficially porous and spongy, and requires the use of the burnisher to bring it back to its original state. This alteration of the surface is attended with a change of weight, and Mr. Dexter has consequently devised the following arrangement:—He removes the air-tube of a common Bunsen lamp, and puts in its place a somewhat longer one of glass or iron, of about 12 millimètres internal diameter. The gas-jet has a single circular aperture, and should be in proper proportion to the diameter of the tube, which may be held in any of the ordinary clamped supports. The tube being raised sufficiently above the jet to allow free entrance of air, and a full stream of gas let on, a "roaring" flame is produced, of which the interior blue cone is pointed, sharply defined, and extends only about half-an-inch from the top of the tube. A polished platinum surface is not acted upon by this flame, provided it be not brought into contact with the interior cone.

In the Bunsen burner, as usually made, the supply of air depends upon the diameter of the tube, the holes at its base being more than sufficient to supply the draught. With the wider tube, it is necessary to limit the admission of air by depressing the tube upon the lamp, when the force of the gas is diminished. Otherwise the proportion becomes such that an explosive mixture is formed. For this reason it is more convenient to use an arrangement in which the excess of air can be regulated by an exterior tube sliding obliquely downward over the air-apertures. The gas-jet should be on a level with the top of these apertures, which must be much larger than those of the ordinary Bunsen's burner.

Mr. Brown, of the War Office Chemical Department, has discovered a remarkable property connected with the ignition and explosion of gun-cotton. He has found that the explosive force of gun-cotton may, like that of nitro-glycerine, be developed by the exposure of the substance to the sudden concussion produced by a detonation; and that if exploded by that agency, the suddenness and consequent violence of its action greatly exceed that of its explosion by means of a highly heated body or flame. It follows, that gun-cotton, even when freely exposed to air, may be made to explode with destructive violence, apparently not inferior to that of nitro-glycerine, simply by employing for its explosion a fuse to which is attached a small detonating charge. Some remarkable results have been already obtained with this new mode of exploding gun-cotton. Large blocks of granite and other very hard rock, and iron plates of some thickness, have been shattered by exploding small charges of gun-cotton which simply rested upon their upper surfaces. Further, long charges or trains of gun-cotton, simply placed upon the ground against stockades of great strength, and wholly unconfined, have been exploded by means of detonating fuses placed in the centre or at one end of the train, and produced uniformly destructive effects throughout their entire length, the results corresponding to those produced by eight or ten times the amount of gunpowder when applied under the most favourable conditions. Mining and quarrying operations, with gun-cotton applied in the new manner, have furnished results quite equal to those obtained with nitro-glycerine, and have proved conclusively that if gun-cotton is exploded by detonation, it is unnecessary to confine the charge in the blast-hole by the process of hard-tamping, as the explosion of the entire charge takes place too suddenly for its effects to be appreciably diminished by the line of escape presented by the blast-hole. Thus the most dangerous of all operations connected with mining may be dispensed with when gun-cotton fired by the new system is employed.

ELECTRICITY.—M. Becquerel, in his sixth memoir 'On Electro-Capillary Actions,' describes the processes which he employed to obtain a great number of hydrated oxides in the crystalline state. In a vessel containing a solution of nitrate of copper, a smaller vessel, one side of which was composed of parchment paper, was placed, containing aluminate of potash. Nitrate of potash was produced, but in the place of aluminate of copper in the porous vessel, crystals of hydrated alumina presented themselves; and on the outside, crystals of hydrated oxide of copper formed. By replacing the aluminate of potash by silicates, M. Becquerel obtained hydrated silica sufficiently hard to scratch glass.

A new arrangement for furnishing currents of electricity has been made known by M. Ney. It is composed as follows:—(1) a vessel filled with solution of chloride of ammonium, containing a plate of amalgamated zinc; (2) a porous cylinder filled with carbonate of copper, into which a plate of copper plunges. To maintain the battery in action, it is only necessary to add solid chloride of ammonium from time to time. In military telegraphy, where the pile should be capable of transport, the outer vessel might be filled with sand saturated with a solution of chloride of ammonium in the place of the solution. This arrangement recommends itself on the score of cheapness, for native carbonate of copper answers sufficiently well, and it likewise only requires attention while in actual use. Carbonate of copper is insoluble in a solution of chloride of ammonium, but upon closing the current, the chloride is decomposed into hydrochloric acid and ammonia; the hydrochloric acid collects at the zinc pole, the ammonia at the copper. The carbonate of copper becomes soluble, and its reduction gives rise to a secondary current having the power of a Daniell's element. This form of battery is perfectly constant.

Mr. Gore has recorded some experiments on the electrolysis of hydrofluoric acid, both anhydrous and hydrated. They are interesting as showing the extreme energy and refractory character of that almost unknown element fluorine. With the anhydrous acid he has used anodes of gas-carbon, carbon of lignum-vitæ, and of many other kinds of wood, of palladium, platinum, and gold. The gas-carbon disintegrated rapidly; all kinds of charcoal flew to pieces quickly, and the anodes of palladium, platinum, and gold were corroded without evolution of gas. The acid with a platinum anode conducted electricity much more readily than pure water; but with one of gold it scarcely conducted at all. These electrolytic experiments presented extreme difficulties, and were conducted in a platinum apparatus specially devised for the purpose. Scarcely more satisfactory results were met with in the experiments of electrolysis of the aqueous acid of various degrees of strength, made with anodes of platinum. Ozone was evolved; and with the stronger acid only, the anode was corroded at the same time.

M. Berthelot has examined the action of the electric spark on marsh gas. When a succession of powerful sparks is made to traverse pure marsh gas, carbon is deposited, and the volume of gas augments considerably. Operating with 100 c. c., this volume becomes 127 c. c. at the end of two minutes, 154 c. c. at the end of ten minutes, and so on; but some hours are required for the complete destruction of the marsh gas. That no marsh gas remains at the end of the experiment may be demonstrated after removing the acetylene and the traces of condensed vapours which are present mixed with hydrogen.

12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY.

Singing Mouse.—A gentleman relates in one of our contemporaries the discovery of a "singing mouse" in his kitchen, which he and his daughters listened to with much delight, the notes being like those of a canary, but very much subdued. He suggests that the mouse may have taken to imitating a canary kept in the house, which he states is the case with field-mice. We need hardly say that this is a somewhat startling explanation; a more likely one is that the singing is the result of spasmodic breathing caused by the presence of a parasite—the *Cysticercus fasciolaris*—in the liver of the poor little songster, since in every case of a singing mouse examined these parasites have been found. But apart from this source of irritation, it is curious that mice should possess the power of singing like a bird. The Rodents are so exceedingly bird-like in many of their habits and structural characters, that one is almost prepared to find some of them able to sing. It is a common mistake to suppose that as a rule birds sing; the vast majority do not. It seems impossible to account for the existence of the faculty in a few birds. Why do they sing? How are they benefited by it in the struggle for existence?

A Sword-fish scuttling a Ship.—A case lately came on before one of the London courts in which the question was raised as to whether a vessel had been struck by a sword-fish, which afterwards had withdrawn its sword, and thus caused a leak which injured the ship's cargo. Professor Owen (who is now travelling Egypt in order to avoid the winter weather) gave evidence as to two cases which had come under his observation, in which sword-fishes had struck vessels; but in both cases the sword had been broken off in the animal's subsequent struggles, thus filling up the hole. The fish's snout in the first case penetrated into fourteen inches of wood; in the second case it had passed right through the timbers and into a berth. In the case under discussion it appeared that only three inches of wood had been penetrated; and Professor Owen thought that a sword-fish might get its nose out of that depth again. The force exhibited in the penetrating power of these blows from the sword-fish is something enormous. The *Xiphias* is a true fish, its sword being formed of two facial bones —the vomer and præmaxillary. It must not be confused with the saw-fish, nor with the cetacean narwhal, whose sword is one of a pair of teeth, which grows to the enormous length of ten feet in some of the males, whilst the other remains small, as do both in the females. The sword-fish and the narwhal are about the same size—a little over twelve feet in length.

The Auditory Organ of Molluscs.—Professor Lacaze-Duthiers has made a very important communication to the French Academy on this subject. Leydig, Huxley and Claparède, and M. Duthiers himself, too, had thought that the otolithic sac of Molluscs, with the exception of Eolidæ and Heteropoda, derived its nerve from the pedal ganglion, since it lies quite on that ganglion; but M. Duthiers has now found that this is a mistake, and that the nerve really comes down to the otolithic saccule from the supra-œsophageal ganglion or brain-ganglion, as in Heteropoda, so that all the organs of sense are presided over by this cerebral ganglion.

The Annelids of the Bay of Naples.—Professor Claparède, of Geneva, having had to pass a winter at Naples for the sake of his health, has produced one of the most beautiful volumes that we have ever seen, on the annelids of its bay. The volume is a quarto one, with thirty-two plates containing innumerable drawings of microscopic structure and detail, and charming coloured figures of the annelids themselves. There is no exaggeration of colour, and the lines are the work of a true artist. Nothing could be more beautiful than the figure of *Phyllochetopterus.* The work is a most important one, moreover, for many new species are described, and— what is of more importance—much that is new in the structure of known forms is told and figured.

A New Type of Polyzoa.—Professor Allman, of Edinburgh, obtained from Mr. Gwyn Jeffreys a most interesting and quite new form of Polyzoa, which was dredged up off the Shetlands. In the 'Quarterly Journal of Microscopical Science' the Professor has described and figured the new molluscoid under the name of *Rhabdopleura.* It is so called from the presence of a remarkable chitinous rod which occupies the centre of the branching tube, in the free ends of which the polypides live. This rod spreads out below the particular cavity occupied by an individual, and there gives attachment to the "funiculus" which attaches the polyzoon to its tube. Another remarkable thing is that the polypides are hippocrepian; but still more important and new is the presence of a convex body on each side of the lophophore, which Professor Allman compares to the mantle of the Lamellibranchs; and he proceeds to show, by two most instructive diagrams, that the resemblance between the Polyzoa and the Lamellibranchs is closer than between them and the Brachiopods, to which they have so frequently of late years been assimilated.

The simplest Living Forms.—In the 'Quarterly Journal of Microscopical Science' for October, Professor Huxley described the viscid substance which abounds everywhere in the mud of the Atlantic bottom, giving to it its sticky character, and containing the small ovoid bodies known as coccoliths—and gave to this substance the name of *Bathybius*, regarding it as an organism probably living by absorption of mineral matter, but not to be certainly referred either to plants or animals. In the same Journal a most interesting paper, by Ernst Haeckel, of Jena, the renowned author of the 'Radiolarien,' and of the 'Morphology of the Organism,' is being published, in which the very lowest forms of animal life—or of life at all—are described—*Protogenes*, *Protomyxa*, *Protomæba*, and others, forming the group Monera—minute bits of living jelly, devoid of all structure, of nucleus, or vacuole, but capable of most active movement, embracing solid food, and digesting it; and at times becoming encysted, and breaking up into spores or gemmules, which grow in time into adult Monera.

Deep-sea Dredgings.—Naturalists have suddenly been aroused to the importance of investigating the fauna of the deepest sea-bottoms with the dredge. Soundings no longer are to be considered satisfactory, but "the dredge, with its iron edge, and mystical triangle" is to explore the ocean-floor at depths of a mile or two. The results obtained by Lovén and Sars incited Professor Wyville Thomson and Dr. Carpenter to a like exploration—their results are most important in what relates to the temperature of the deeper currents. Dr. E. P. Wright's little excursion off Portugal, where he dredged in 600 fathoms, produced some interesting facts, besides the confirmation of Bolage's discovery of *Hyalonema;* especially as to the presence of a shark and of *Chiasmodon* at these depths. On what do these fishes feed? The American dredgings, however, promise to be the most interesting, and the most fully carried out. The Superintendent of the Coast Survey (why have we not one likewise in England?) no sooner perceives the importance of these dredgings than he arranges for deep-sea dredgings in the region of the Gulf Stream—actually within the Gulf of Mexico. Mr. L. F. de Pourtales has had the direction of this matter, and gives a most promising account of dredgings at a depth of 400 to 500 fathoms, and also at 300 fathoms. In this last region he found the most common mollusc to be *Terebratula Cubensis*—a new species; and also a *Waldheimia*, both of large size. This Terebratula is of great interest; for before this, only two living species of that genus—so abundant in Oolitic and Cretaceous times—were known: the one, *T. vitrea*, found in the Mediterranean; the other, *T. uva*, a unique specimen from the coast of Mexico. This tends to confirm the idea of Sars—that in these deeper parts of the sea-bottom many forms thought to be extinct may be still lingering on—or at any rate be represented—not able to encroach on the fauna which occupies the shallower water, but kept down by the advancing coast-fauna to the lower regions, like prisoners in a dungeon. The case is comparable to that of "Alpine" floras, which are now kept to the top of high hills and mountain slopes, but which must once have spread from these spots to Arctic regions. Mr. de Pourtales found Gasteropods rare at a depth of 300 fathoms, Acephala rare and small, but Bryozoa abundant. The most common Echinoderm was a new species of *Cidaris*, besides which there were other forms, and a new *Psolus*. Eighteen new species of corals, and other new Cœlenterates are mentioned. No sea-weeds were obtained. Some animal remains were found whose presence is accidental, such as sharks' teeth, bills of Cephalopods, shells of Pteropods, and fragments of bones of the Manatee. A new Crinoid (probably the same as the *Rhizocrinus* of Sars), considered to belong to the genus *Bourgueticrinus* of D'Orbigny, was obtained—possibly identical with a species found fossil in Guadaloupe. In the presumed absence of vegetable life, we may fairly ask, What do these animals feed on? They cannot eat one another, or there would soon be an end to them. Must we suppose that the *Bathybius* of Professor Huxley is here organizing food from mineral matter?

The Fauna of the Victoria Docks.—Mr. Kent, of the British Museum, at one of the excursions of the Quekett Club to the Victoria Docks, discovered a new Nudibranch, of the genus *Embletonia*, which he calls *E. Grayii*, also a new Polyzoon, large numbers of a species of Mysis, the respiratory organs of which he has been investigating, and besides these, that most interesting fresh-water Hydrozoon, *Cordylophora*. These interesting forms are associated with a vast variety of fresh-water Rotiferæ, Entomostraca, and Infusoria. The occurrence of *Embletonia* in this position is exceedingly interesting. It appears from some observations of Dr. Gray, that *Embletonia pallida* is found in the Baltic, extending far up into that part of the sea where the water becomes almost fresh. Hence the occurrence of the genus in the brackish or nearly fresh-water of Victoria Docks is not without parallel. It is an important subject for inquiry, as to how the fauna of the Victoria Docks originated. Is it the representative of an ancient marsh fauna, presenting in its Nudibranch and Hydrozoon an indication of the recession of the sea? Or has Embletonia been introduced with ships and established itself, and has *Cordylophora*, long since adapted to lacustrine conditions, also been introduced since the time when the area was a marine one?

PHYSIOLOGY.

Influence of Section of the Pneumogastric Nerves on Respiration.—Herr Voit, of Munich (a physiologist, whose writings on the subject of the connection between muscle-oxidation, food, and muscular work, as opposed to Liebig's old teaching, were of much value, and of early date in the late revulsion of scientific opinion on that subject), has experimented on the effect of cutting the pneumogastrics as to respiration. Previous experimenters have shown that the amount of carbonic acid exhaled after section of the nerve, is the same as that before. The author and Dr. Raber find now that this is true only for the first few hours after the operation. At a later period when the tissue of the lung has begun to undergo a change, the quantity of carbonic acid diminishes rapidly, and that of oxygen is increased.

Influence of Respiration on the Temperature of the Blood.—Dr. Lambard, of whose wonderfully delicate thermo-electric apparatus we spoke in our last Chronicle in relation to the temperature of the head, capable as it is of indicating a difference of temperature of about $\frac{1}{2000}$th of a degree centigrade, has been applying his instrument to the study of the effects of respiration on the temperature of the blood. One apparently anomalous result which he obtained is this—though the air taken into the lungs, and consequently into the blood, be quite cold and dry, it does not lower the temperature of the blood sufficiently to be appreciable by this delicate thermometer, as compared with the temperature when the air respired is hot. We must all of us have noted the feeling of heat in the lungs on a cold frosty day—a sensation which is not experienced in warmer weather, and which is the very reverse of what we should expect from the greater coldness of the inspired air. M. Brown-Séquard suggests that the explanation may be this—the lower the temperature of the inhaled oxygen the greater will be the amount absorbed according to a well-known law in physics, and hence possibly, there being a larger absorption of oxygen, there may be increased oxidation, and increased heat accordingly. The tension of the vessels affected by cold air, may have some connection with the sensation in the lungs.

Poison of Snakes.—M. Vulpian, of Paris, a well-known physiologist, received some dry and some moist poison of the Cobra di capello, which had been forwarded from India by Mr. Shortt. He proceeded to try its effects upon frogs, rats, and rabbits, and had especially in view the object of testing the truth of Dr. Halford's observations as to the extraordinary increase of white corpuscles in the blood of bitten animals. In the condition in which he was able to study it—a condition in which its activity is without doubt notably diminished—M. Vulpian found that the poison appeared to act on the central nervous system, the functions of which it little by little suppressed, producing a state of somnolence of a remarkable kind. In frogs it produces an effect similar to that induced by curare; it abolishes the action of motor nerves on the muscles as regards contractility. The movements of the true heart persist some time after death, whilst those of the lymphatic hearts cease very soon, as in frogs poisoned by curare. It is hardly necessary to say that the results of the action of the poison of the Cobra di capello, relatively to the muscles and to the nerves, has nothing peculiar about it; for we know now more than twenty toxic substances which destroy the function of the motor nerves as regards muscular contractility. As to the blood, M. Vulpian has *not* confirmed the existence of the modification described by Halford, and has seen nothing at all like it. He finds (and this is a peculiarly interesting fact) that the buccal mucous membrane is capable of absorbing the poison, and that the same symptoms are produced as when the poison is absorbed from a wound. Those who have had the opportunity have lately been busy in examining snake-poison.

A writer in the 'Lancet' details some experiments, in which he failed to produce the effect on the blood described by Halford and by Jones. It appears to us quite possible that the intensity of the poison might affect this condition very much, and that while being sufficiently powerful to kill, M. Vulpian's specimens of poison may have failed to produce the exaggerated leucœmic condition simply from the loss of intensity or of a special quality acting on the blood itself or on the hœmopoietic glands. Some remarkable cases of cure from snake-bite are reported in the medical journals, as effected by Dr. Halford in Australia, by the injection of ammonia subcutaneously and into the veins. Ammonia has long been used as a stimulant in these cases, and the injection seems to be merely a more direct method of application, the object being to counteract the drowsiness which comes on. Colonel Showers records some striking instances of cure from snake-bite effected by a native Hindoo with certain herbs. If M. Vulpian is right in regarding the mode of action of snake-poison as similar to that of curare, it seems not improbable that vegetable principles should exist having an opposite physiological effect, and therefore capable of neutralizing it.

An Experiment with a Scorpion.—Mr. Frank Buckland gives an amusing account in his 'Land and Water' of a fight between a mouse and a scorpion. He received two scorpions from Egypt through Mr. J. Keast Lord, who is now exploring the Red Sea for the Viceroy, and turned one of them into a bell jar with a freshly-caught mouse. The scorpion was not one of the big African species, but a little fellow, the body being about the size of a large cockroach, and the tail of course additional. He carried this last over his head, and when brought up to the mouse let out with it in furious style, stabbing the mouse several times, who did not seem to mind it much, except one blow received on the nose which he wiped with his fore paw. The mouse proceeded to bite off two of the scorpion's legs and also injured his tail so that he could not sting. Mr. Buckland expected after a while to see the scorpion's poison take effect, but nothing of the sort ensued, and the last scene in the drama was the mouse quietly devouring the body of its late antagonist. The journey from Egypt in a box without food, and in cold weather, doubtless had affected the scorpion's secreting powers; he was suffering from an exhausted nervous system.

Quarterly List of Publications received for Review.

1. The Malay Archipelago. The Land of the Orang-Utan and the Bird of Paradise. By Alfred Russel Wallace. 2 vols. *Illustrated with Plates and Woodcuts.* *Macmillan & Co.*
2. The Polar World. A Popular Description of Man and Nature in the Arctic and Antarctic Regions of the Globe. By Dr. G. Hartwig. *With* 8 *Chromolithographs and Woodcuts.* *Longmans & Co.*
3. The Theory of Ocular Defects and of Spectacles. Translated from the German of Dr. Hermann Scheffler. By Robert B. Carter, F.R.C.S. *Longmans & Co.*
4. On Molecular and Microscopical Science. By Mary Somerville. 2 vols. *With Illustrations.* *John Murray.*
5. Circle of Light, or Dhawalegeri. By H. P. Malet. *J. C. Newby.*
6. Sciography; or, Radical Projection of Shadows. By R. Campbell Puckett, Ph.D. *Chapman & Hall.*
7. Underground Life; or, Mines and Miners. By L. Simonin. Translated and Edited by H. W. Bristow, F.R.S. *Illustrated with* 160 *Wood Engravings,* 20 *Maps, and* 10 *Chromolithographs.* *Chapman & Hall.*
8. Lectures on the Preservation of Health. By Chas. A. Cameron, Ph.D., M.D. *Woodcuts.* *Cassell, Petter, & Galpin.*
9. Physical and Historical Evidences of vast Sinkings of Land on the North and West Coasts of France and South-Western Coasts of England, within the Historical Period. R. A. Peacock, C.E. *E. & F. N. Spon.*
10. Handbook of Natural Philosophy. By D. Lardner, D.C.L. Optics. Sixth Thousand. Edited by T. O. Harding, B.A. *James Walton.*
11. Preglacial Man, and Geological Chronology. By J. Scott Moore. *Dublin: Hodges, Smith, & Foster. London: Williams & Norgate.*
12. Facts and Arguments for Darwin by Fritz Müller. Translated from the German by W. S. Dallas, F.L.S. *John Murray.*
13. Medicine in Modern Times. By Dr. Stokes, Dr. Acland, Professor Rolleston, Rev. Prof. Haughton, and Dr. Gull. *Macmillan & Co.*

PAMPHLETS AND PERIODICALS.

Observations on the Spectra of some of the Stars and Nebulæ, &c.; also Observations on the Spectra of the Sun and of Comet II., 1868. By William Huggins, F.R.S.

On the Home Produce, Imports, and Consumption of Wheat. By J. B. Lawes, F.R.S., and J. H. Gilbert, F.R.S. *Longmans.*

Vital Law. *Longmans.*

On the Coal Measures of the Neighbourhood of Rotherham. By A. H. Green, M.A., Geol. Survey.

On the Prevention of excessive Infant Mortality. By Mrs. Baines.

On the Condition of the Metallic Currency of the United Kingdom, with reference to the Question of International Coinage. By W. Stanley Jevons, M.A. *Harrison & Sons.*

Notes on the Extinct Floras of North America, &c. By J. S. Newberry, Columbia College, New York.

On the Origin of Genera. By E. D. Cope, A.M. *Philadelphia: Merrihew & Son.*

More Light. *Wyman & Sons.*

On the Influence of Mind on the Molecular Forces of Matter. By Dr. J. B. Nevins.

Invention of the Electric Telegraph. *Simpkin, Marshall, & Co.*

Revue Bibliographique Universelle. *Paris: Aux Bureaux de la Revue.*

Polytechnisches Notizblatt für Gewerbtreibende, Fabrikanten und Künstler. Herausgegeben und redigirt v. Prof. Dr. R. Bœttger in Frankfurt. a. M. *C. G. Kunze's Nachfolger.*

Nachrichten von der Königl. Gesellshaft der Wissenschaften und der G. A. Universität zu Göttingen.

Revue Hebdomadaire de Chimie Scientifique et Industrielle, sous la Direction de M. Ch. Mène. *Paris: Ch. Mène.*

Catalogue of American and Foreign Scientific Books for Sale by *D. van Nostrand, New York.*

Van Nostrand's Eclectic Engineering Magazine. *Same Publisher.*

The American Naturalist.

The Geological Magazine. *Trübner & Co.*

The Canadian Naturalist and Geologist.

The Quarterly Journal of Microscopical Science. *J. Churchill & Sons.*

The Westminster.

Scientific Opinion.

The Popular Science Review. *Hardwicke.*

The Public Health.

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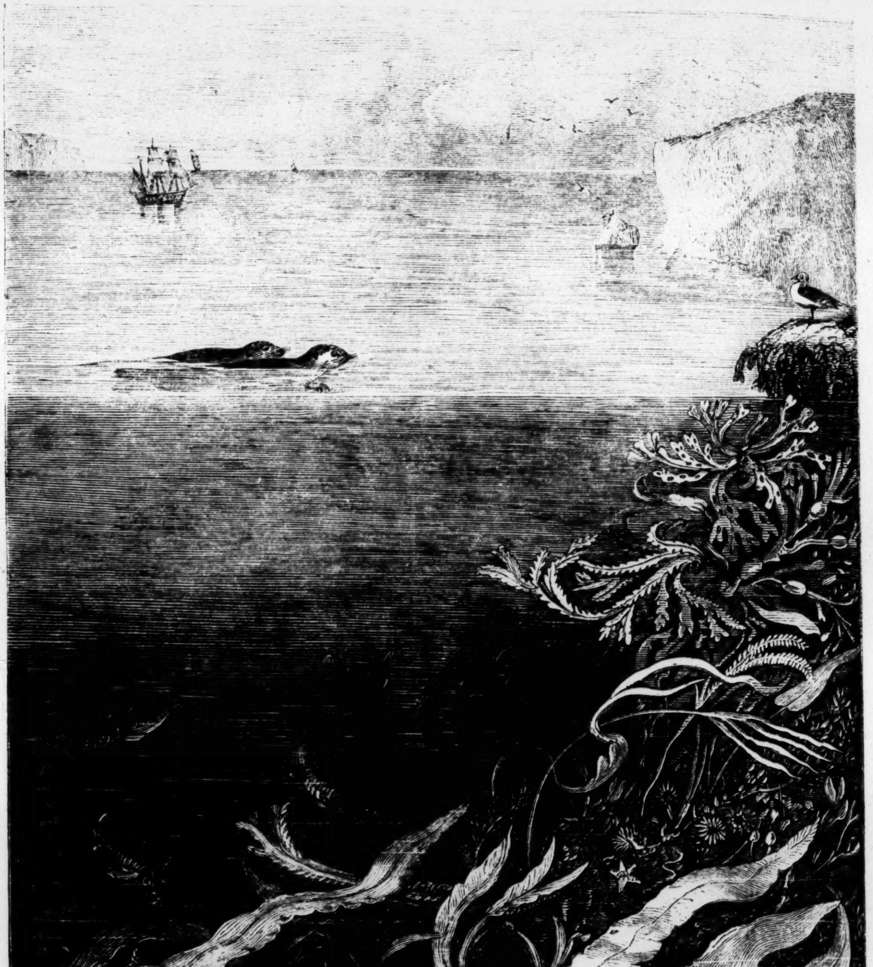

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